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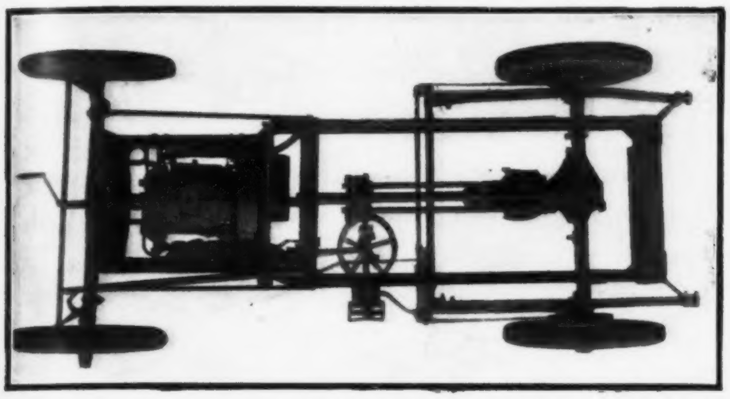
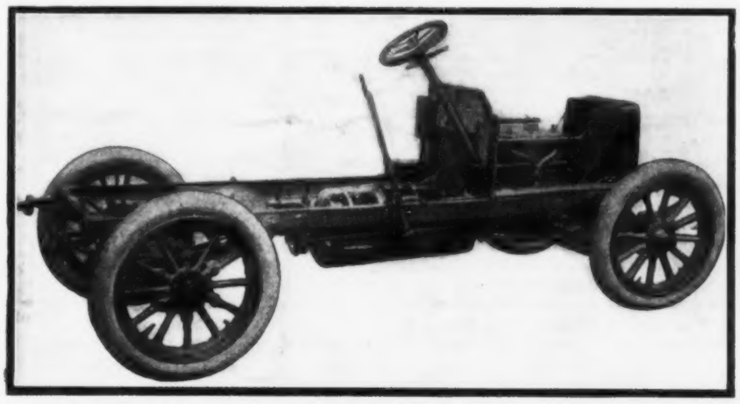
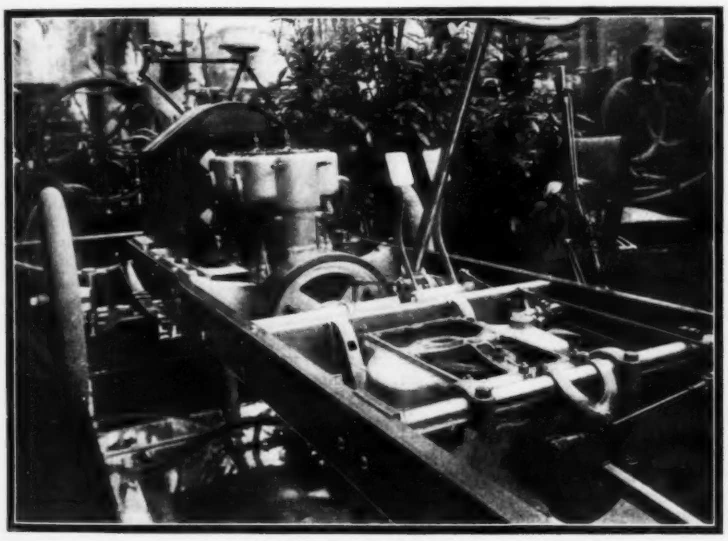


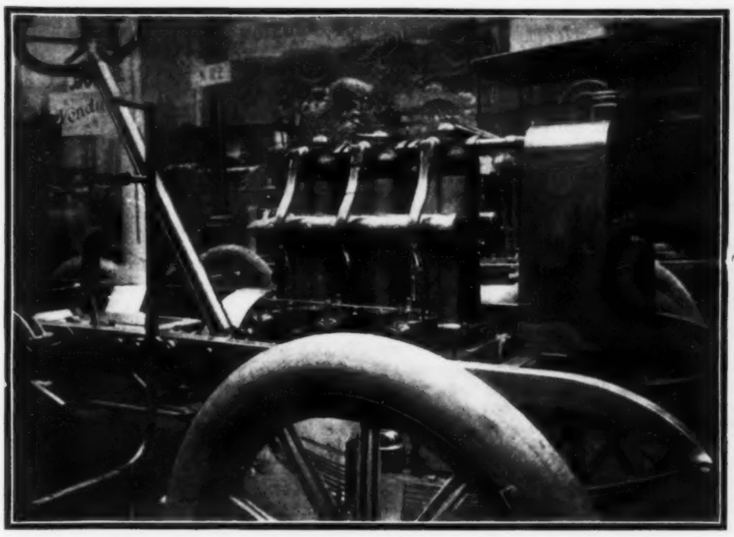
TRANSMISSION AND DIFFERENTIAL ON REAR AXLE OF DENIS-DE BOISSE CAR.



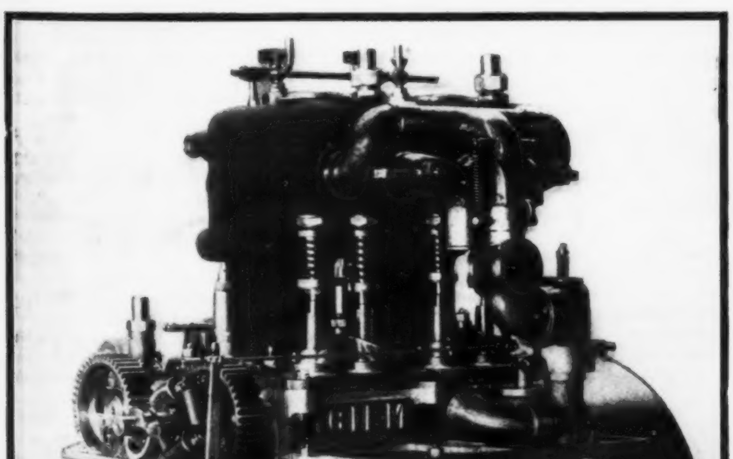
CHASSIS OF SAGE GASOLINE CAR HAVING NOVEL ELECTRIC TRANSMISSION.



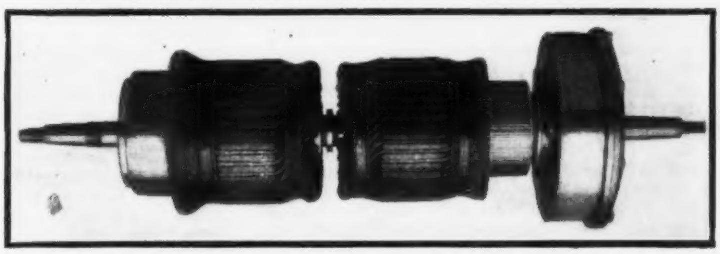
CHASSIS OF PIVOT CAR HAVING LATEST TYPE OF TRANSMISSION GEAR.



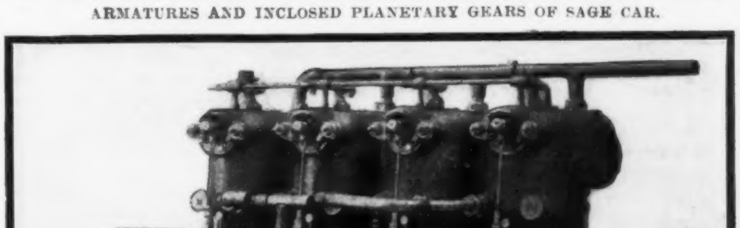
THREE-CYLINDER TWO-CYCLE MOTOR OF LEGROS AUTOMOBILE.



LATEST TYPE TWO-CYLINDER THURY MOTOR.



ARMATURES AND INCLOSED PLANETARY GEARS OF SAGE CAR.



TYPICAL FRENCH MOTOR.

SOME MOTORS AND TRANSMISSIONS AT THE RECENT PARIS AUTOMOBILE SHOW.

[Continued from SUPPLEMENT No. 1514, page 24262.]

THE 1904 PARIS AUTOMOBILE SHOW.—II.

By the Paris Correspondent of SCIENTIFIC AMERICAN.

PIVOT SYSTEM.

THE main point of interest in the Pivot automobile is the new speed-changing box. This is illustrated in the general view of the chassis, and the diagram shows its operation. The motor crank shaft is at *M*. In line with it, but separated from the motor at the point *e*, is the shaft, *P*, which passes back to the rear axle of the car. The latter is supported by a ball-bearing at *b*, while the shaft, *M*, is coupled to *P* by a socket bearing at *e*. Parallel to *MP* is the countershaft, *N*. It carries two fixed gears, *D* and *C*, while the shaft, *P*, carries two fixed gears, *F* and *E*, of different diameters. The sliding gear set, *AB*, can be shifted to and fro upon a square portion of the shaft, *M*, by means of a cam device. In like manner the sliding set, *HG*, can be moved upon the shaft, *N*.

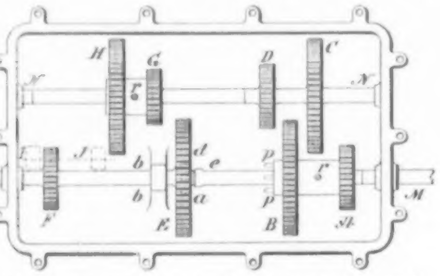


DIAGRAM OF PIVOT TRANSMISSION HAVING TWO SLIDING GEAR SETS.

This mechanism produces four direct speeds and a reverse. For the first, or slowest speed, the set *AB* is shifted to the left in order to bring *A* in mesh with *C*. At the same time the set *GH* is moved so that *G* meshes with *E*. Thus we have *M* connected with *P* by way of *A*, *C*, *G*, and *E*. For the second speed, the gear, *G*, remains in mesh with *E*, while *A* is shifted out of mesh with *C*, and *B* comes opposite the gear, *D*. This gives the combination *BDGE*. Leaving *B* and *D* still in mesh, we next shift *GH* to the left so that *G* leaves *E* and *H* comes opposite *F*. We then have the third speed, or *BDHF*. For the full speed of the motor on the rear of the car, the motor shaft is coupled direct to the shaft, *P*, and all the intermediate gearing is thrown out of action. This is accomplished by shifting *H* away from *F* and at the same time the gear set *AB* is brought to the extreme left, where *B* comes against *E*. The gear, *B*, carries a set of projections, *p p*, which fit into the sockets, *a d*, in the gear *E*, thus interlocking the two and giving the direct drive.

To carry out the movement of the two sets, *AB* and *GH*, in connection with each other at the proper time, both sets are operated by a cam which is placed on top of the gear case. This consists of a flat plate which turns about a central point above the shafts *M* and *N*. The under surface of the plate carries a pair of grooves into which fit the vertical rods *r r* of each gear set. By turning the plate about its center the circular movement causes a lateral movement of the sliding gears and the profile of the cam is calculated to work the two sets at the right moment. The reverse is obtained by using a pair of small gears which are mounted on a short piece of shaft and placed in the bottom of the case. The pair of gears can be shifted as a whole to the right or left. In the diagram the gears are placed on the left and are out of action. For the reverse the pair is shifted to the right so as to connect the gear *H* with *F* by means of the combination *HJIF*. In this case the shaft, *N*, which is connected with *M* by the gears *AC*, now drives the shaft, *P*, in the opposite direction. The above system has several advantages. One of these is that we have two sets of sliding gears to connect the motor with the rear shaft and the wear on the teeth from shifting the gears is less in consequence. Another is that the successive speeds are obtained without having to pass the teeth of one gear completely through another, but the gears clash from one side alone, which gives an easier movement.

MENDELSSOHN.

An automobile which presents some novel points of construction is the Mendelssohn car. The gear case is shown in the engraving and diagram. For a constant speed of the motor shaft, *D*, we obtain four different speeds and a reverse on the rear shaft, *C*. The latter is supported in a rear bearing and by an interior bearing, *B*, in the shaft, *D*. The gear, *A*, is mounted upon *D*. The shaft, *C*, is square along the middle portion, *E*, and carries two sliding pieces, *F* and *G*. The piece, *F*, is composed of a gear provided with a set of projections forming one-half of a jaw-clutch, while *G* consists of two gears of unequal diameters. A countershaft, *H*, serves as an intermediary for three speeds and the reverse, while the fourth speed is obtained by a direct drive. The shaft, *H*, is square and carries three series of pieces which slide upon it—the gear, *I*, the double gear, *J*, and the pinion, *K*. The pieces *F*, *G*, *I*, *J*, *K* can slide independently of each other by means of a set of cams placed at the top of the box and worked from the driver's lever.

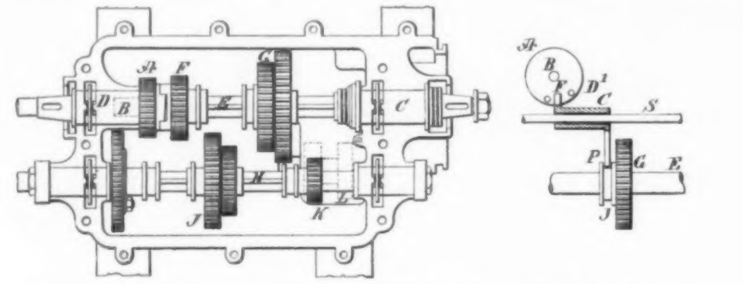


DIAGRAM OF MENDELSSOHN TRANSMISSIO; AND OPERATING MECHANISM.

The first position (which is shown here) is that of full speed. *F* is connected with *D* by the jaw-clutch and the motor gives a direct drive on the rear shaft. In the second position, *F* is moved to the right so as to come in contact with *J*, and at the same time *I* (the gear at the extreme left of case) is shifted so as to mesh with *A*. This gives the third speed. Leaving *I* and *A* in contact, *J* is moved to the right, and its small gear comes opposite the small pinion of *G*. We now have the second speed. Next, *G* advances to the right and its large gear comes in mesh with *K*, which gives the slowest speed. For the reverse, the pinion, *K*, is moved to the right and comes in contact with the double gear, *L*, which is placed below.

The method of shifting the gears will be understood by referring to the engraving and also to the second diagram. Each gear set, such as *G*, slides upon the shaft, *E*, as above shown. At the top of the box is a set of rods, *S*. Each rod carries a collar, *C*, which controls the gear by the projections, *P*, working in the collar, *J*, on the gear. The pieces, *C*, are shifted to the right or left by means of a lug, *F*, and the projections, *DD'* upon the disk, *A*. The four disks, *A*, are mounted on a common shaft, *B*, which is turned by the driver's lever. The cams are adjusted so that the progressive movement of the driver's lever shifts the gears properly for the different speeds.

It is observed that the four speeds and reverse are obtained by the alternate displacement of the pieces upon two parallel shafts. This differs from the usual method. The advantages are that we have equal amplitudes of movement and thus the cams are identical and interchangeable. Second, the length of the gearbox is reduced to a minimum. Third, the teeth of one gear do not slide through the corresponding gear completely as in the usual case, but enter it from one side alone, and thus the tooth is only beveled off on one side, which gives a greater working surface for the tooth. Again, the ratio of the speed gearing can be easily changed by taking out certain pieces, such as *G* or *J*, and replacing them by others without having to change the shafts.

DENIS-DE BOISSE.

The Denis-De Boisse system shows several new features, which can be seen in the view of the chassis. Starting from the motor, one of the points to be noted is the new all-metal friction clutch. It has four bronze friction shoes which are applied against the inner surface of the clutch disk. They are thrown on progressively by means of a lever. The system avoids the jerking movement which sometimes occurs owing to the sticking of the ordinary leather surface clutch. It has a remarkably easy movement and has another advantage in allowing a certain displacement of the shaft with relation to the motor shaft, seeing that the four shoes are mounted on universal joints.

The disposition of the speed-changing box, which is now placed in the extreme rear and against the differential, is another feature which will be noticed in the chassis. The friction clutch is now connected with the rear by a single long shaft carrying a universal joint at each end. The method which has been adopted for shifting the gears gives the chassis an original appearance. In principle the method closely resembles the above, and each of the gear sets is independent and operated by a rod. But in this case the rod is controlled by a long shaft which carries a universal joint and passes forward to the middle of the chassis. The four shafts are brought together in a fixed circular support. A shaft runs from here to the driver's lever on one side, so that the movement of the lever controls all four rods one after the other by means of a suitable device placed in the supporting piece.

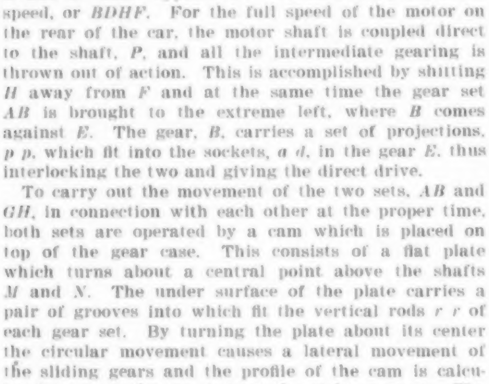
Owing to the fact that the speed-changing box is now especially small, in fact it measures but 5 inches between bearings, it is stronger than usual and suppresses the effect of bending which is apt to occur in a box having a long shaft. The speed-changing box is fastened to the differential by two hollow bolts which serve also as part of a special oiling system for the gearing.

The system is automatic and utilizes the rotation of the large bevel gear of the differential for projecting the oil into a cavity which is cast in the box. From here it passes through the hollow bolt which holds the two boxes together and from there drops into an oil-hole on the left, so as to oil the main shaft. From there it passes to the lower part of the box, oiling the main gears, and thence returns to the differential case through the lower hollow bolt. This device suppresses the oiler which is usually placed on the dashboard.

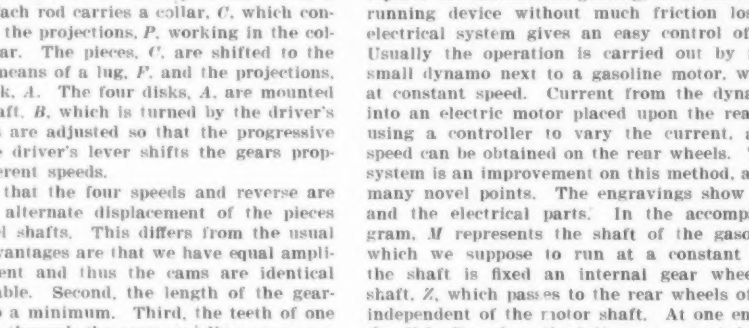
SAGE ELECTRIC SYSTEM.

The electrical method of transmitting the power of the gasoline motor to the rear of the car is intended to replace the mechanical gearing, as it affords a smooth running device without much friction loss, and the electrical system gives an easy control of the speed. Usually the operation is carried out by mounting a small dynamo next to a gasoline motor, which is run at constant speed. Current from the dynamo is sent into an electric motor placed upon the rear axle. By using a controller to vary the current, any desired speed can be obtained on the rear wheels. The present system is an improvement on this method, and contains many novel points. The engravings show the chassis and the electrical parts. In the accompanying diagram, *M* represents the shaft of the gasoline motor, which we suppose to run at a constant speed. On the shaft is fixed an internal gear wheel, *R*. The shaft, *Z*, which passes to the rear wheels of the car, is independent of the motor shaft. At one end it carries the disk, *P*, and on the latter are mounted three small gears, *S S S*, each of which rotates upon a stud and engages with *R*. The gears, *S*, also engage with a central gear, *K*, which is mounted on the end of the collar, *J*. The combination *JK*, turns upon the shaft, *Z*, and is independent of the latter. We may suppose that the motor runs at 1,000 revolutions per minute and that the diameter of *K* is one-half that of *R*. In consequence, the pinions, *SS*, are one-fourth the diameter of *R*. Under these conditions, if the motor shaft runs at the full speed, it causes the pinions, *S*, to turn on their axes, and the pinion, *K*, which offers no resistance will run in the opposite direction from *M* and at a speed of 2,000 revolutions.

As to the shaft, *Z*, which offers a resistance—that of the automobile itself before starting for instance—it will remain stationary. Suppose that we put a brake on the collar, *J*, and apply it sufficiently to block the pinion, *K*. In that case the shaft, *Z*, and the plate, *P*, carrying *S* will commence to turn in the same direction as *R*, or the motor shaft, and at a speed equal to two-thirds of the motor speed. Instead of blocking the collar, *J*, completely we may apply the brake gradually and thus diminish the speed of the pinion *K* from 2,000 revolutions per minute to zero. At the same time the speed of *Z* will be increased from zero to two-thirds of the motor speed. In place of using a friction brake upon *J* we may mount a dynamo upon this part, connecting it to a variable resistance. By changing



TRANSMISSION OF MENDELSSOHN CAR.

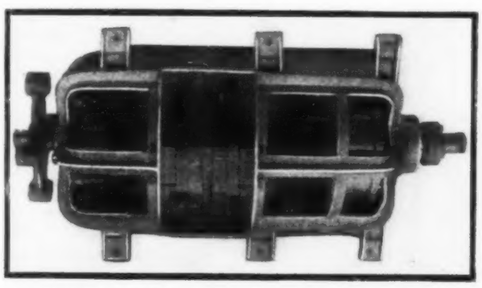


DIAGRAMS SHOWING CONSTRUCTION OF SAGE ELECTRIC TRANSMISSION.

the resistance we allow the dynamo to generate more or less current and it thus acts as a magnetic brake and varies the speed of the mechanism in the same way as above. But in either of the above cases a great part of the energy is lost either in the mechanical friction of the brake or in the resistances of the dynamo in the form of heat. One of the original features of the present system is to use the current produced by the dynamo to operate an electric motor on the driving shaft and the latter serves to restore all the energy absorbed by the former, excepting the small waste in transforming. This arrangement has several advantages as regards the speed variation.

The above mentioned dynamo has its armature, A_1, placed on the collar, J, and surrounded by the field, F_2, while the motor is mounted directly on the shaft, Z. When the dynamo is started as we have just seen, it has the effect of slowing down the pinion, K, and at the same time it generates current. The motor is electrically run by current from the dynamo. Suppose that we wish to start the car. The engine has been running meanwhile at the full speed and the dynamo armature of the electric motor turns, as we saw, at 2,000 revolutions per minute, but does not generate current. By coupling this with the motor we cause it to produce current and it slows down, acting as a brake to a certain extent. Consequently the action above described takes place, and the shaft, Z, commences to rotate. But the current from the dynamo is sent meanwhile into the motor armature, which thereupon tends to rotate the shaft, Z. Its power is thus added to that of the gasoline motor, aiding it to turn the shaft, Z, and recuperating the energy which would have been lost in the brake action in the form of heat.

By varying the resistance of the circuits we thus obtain different conditions of running, from zero up to full speed of the motor and even beyond. The operation of the two machines is varied by shifting the brushes of their commutators around a circle, thus regulating the electromotive force of each without needing to use resistance coils or a controller, as is generally the case. At the starting, A_1 acts as a



TOP VIEW OF THE SAGE ELECTRIC TRANSMISSION.

generator and A_2 as a motor, and this action increases up to a certain point, when A_2 stops its movement and the action of the two machines is reversed. A_1 now becomes the generator and A_2 the motor. Here the gear, K, commences to turn in the contrary direction and now runs the same way as R, so that its speed is now added to the latter in order to accelerate the movement of the shaft, Z. We now come to the moment where A_2 runs at 1,000 revolutions per minute, or at the same speed and direction as the motor shaft, M, and here the whole system, R, S, and K, turns together with the shaft Z and at the normal speed of the motor.

Continuing the movement of the dynamo brushes we can exceed this speed and reach 1,233 revolutions. Thus, by simply rotating the brushes, we can bring the shaft, Z, from zero up to 25 per cent in excess of the motor speed. By another movement we also obtain the reversal of Z for running the car backward. A simple handle on top of the steering wheel serves to shift the brushes of the dynamos and gives all the variations in speed.

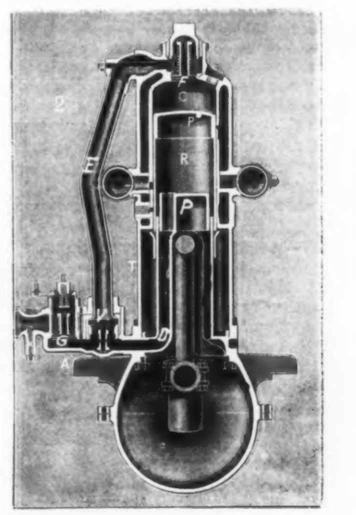
The above system gives a great latitude of movement with but little mechanical friction. It also allows the gasoline motor to run at constant speed, which is an advantage. Should an accident happen to the dynamos, the car can be run direct by the engine by blocking the part, JK, with a brake. It should be noticed that the efficiency of the present system, as regards loss of power in the dynamos, is higher than with the ordinary electric transmission, seeing that only a part of the power, at most one-quarter, is transformed to electrical energy, and we must count the losses only upon one-quarter of the total power. Admitting a gasoline motor of 20 horse-power and an efficiency of both dynamos of 75 per cent, we thus have 18¾ horse-power delivered on the rear shaft, while in the case where we have an electrical transformation of the total power, we now obtain but 15 horse-power available. For the same reason the dynamos can be of a much smaller capacity than if they had to transmit the whole power of the gasoline motor.

LEGROS SYSTEM.

Among the novelties in the way of automobiles must be mentioned the Legros car, which is shown in our engraving. It is distinguished by the fact that it uses a motor which operates on the two-cycle system instead of the usual four-cycle. The present car is equipped with a three-cylinder motor which is claimed to have most of the advantages of a six-cylinder motor of the ordinary type, while it has a marked gain in simplicity. The Legros motor is based on a new principle of construction, different from that which has been adopted for most of the two-cycle gasoline motors. As will be noticed in the sectional view, the piston, P', which works in the cylinder, C, has inside it a fixed piston, P. The piston, P', when ascending, causes the necessary suction for admitting the gas to the motor, and, on its downward stroke, forces the gas to the explosion chamber. The gas is admitted by the inlet valve, G, and it passes into the chamber which is formed inside the piston, P', by the tube, D, which is placed on one side of the fixed piston. A pipe, E, of large diameter connects the inlet tube with the top of the motor, terminating in the valve, F. There is also a valve, V, at the bottom of the pipe, E.

As in all two-cycle motors, we have one motive period per revolution of the shaft and per cylinder, but here the cycle is as well defined as in a four-cycle motor. The cycle is carried out as follows: The downward movement of the piston is caused by the explosion of the gas in the cylinder, C, and is followed by the expansion of the gas. The latter then escapes by a series of openings which the piston uncovers when it arrives at the bottom of the stroke. During the previous ascending movement of the piston, a quantity of gas was drawn into the chamber, R, inside the piston, through the tube, D, by suction, and in the descent of the piston this gas was compressed in the pipes, D and E. At the proper moment of the descent, the gas enters the top of the cylinder through the valve, F, as soon as the burned gases have escaped by the holes below. When the piston ascends again, it covers the exhaust holes and then begins to compress the gas in the explosion chamber. When at the top of the stroke, a spark explodes the gas and the piston descends, carrying on the cycle as before.

One advantage in the present design is that the



CROSS-SECTION OF THE LEGROS TWO-CYCLE MOTOR.

gas is well mixed in the chamber, R, before it is allowed to enter the explosion chamber, and the vaporization of the gasoline is complete. The gas is then introduced into C without a sudden rush, and at the same time the symmetrical arrangement of the exhaust holes assures the proper discharge of the burned gases without causing any loss of fresh gas. Without dwelling upon the advantages of the two-cycle motor, we may remark the frequency of the motive couple which is thus obtained without increasing the number of cylinders and especially of the pieces in movement. The regular succession of explosions at equal intervals is favorable for the mechanical balance of the motor. The number of cylinders is reduced one-half to obtain the same flexibility and the same number of explosions as in a four-cycle motor. With a two-cylinder motor we thus have all the advantages of a four-cylinder four-cycle motor, with a great gain in simplicity. With the new three-cylinder type, which is illustrated here, we obtain a distribution and frequency of effort on the shaft which it would require six cylinders of the usual kind to produce.

HARD-SOLDER FOR ENAMELING PURPOSES.

THE designation "hard-solder" is given to the preparation that we are about to describe, to distinguish it from the easily running and softer solder used by tinsmiths, and it applies solely to a composition that will not flow under a red heat.

For the purposes of the jeweler we distinguish solder according to its composition and purpose, into gold or silver solder, which means a solder consisting of an alloy of gold with silver, copper, tin, or zinc-like metals or an alloy of silver with copper, tin, or zinc-like metal.

According to the uses, we make the solder hard or soft; thus in gold solders we add a greater amount of silver, whereas for silver solders we add more tin or zinc-like metal.

In the production of solder for the enameler's use, that is for combining gold with gold, gold with silver, or gold with copper, which must be enameled afterward, it is necessary to keep always before your mind that no solder can be used effectually that contains any tin, zinc, zinc-alloys, or tin or zinc-like metals in any great quantities, since it is these very metals that contribute to the cracking of the enamel.

And yet it is not possible to do without such an addition entirely, otherwise the solder would not flow under the melting point of the precious metals themselves and we should be unable to effect a union of the parts. It is therefore absolutely necessary to confine these additions to the lowest possible percentage, so that, in a way, only a trace is apparent. Moreover, care must be taken to use for enameling purposes no base alloy, because the holding qualities or durability of the compound will be affected thereby; besides, we must not lose sight of the fact that it is subject to governmental control; in other words, it must come up to the standard or receive no hall mark.

The alloys which we shall give here are divided into 1,000 parts and are calculated only for red gold alloys; to solder gold alloys of fine gold another composition must be found, since the melting of the solder given here is higher than that of gold alone and consequently no soldering of the object could take place without melting it.

Gold Solder for Enameling.

Fine gold	600 parts
Copper	150 parts
Fine silver	250 parts
Cadmium, a trace.	

We see then that this solder contains 600-1,000 fine gold and is serviceable for all purposes, even when the finished product is to be subjected to governmental assay and mark, because the application of the solder can be very economically done.

Spelter may be substituted for the cadmium but care must be taken in either case that the alloy itself, that is, the gold, copper, and silver, be completely fluid and ready to pour out, when just before pouring out the cadmium or spelter be added. If the latter addition should remain in the melting pot under such a heat for any length of time, it would undoubtedly be badly burned and the usefulness of the solder would be greatly impaired. By a trace we mean about 0.1 gramme of cadmium or spelter to 10 grammes of the alloy. In smaller ratios it would not pay to melt it in a crucible, but melting it upon charcoal under the blowpipe is preferable, because by close observation the correct moment for pouring it out can be fixed, as well as the right time to add the spelter.

It may be of interest also for those who have the work to do to learn of a good process for melting it upon the charcoal. In a large piece of charcoal without cracks prepare a hollow in which the metals are placed; from this to one end of the piece of coal cut out a channel which lies in the same plane as the middle part of the hollow and which empties into a mold fastened to the end of the coal. The mold is made of sheet iron and can be prepared by any goldsmith; it has an entrance rim and is covered with a piece of the same metal fastened to it with wire. One operator now directs the blowpipe flame upon the metals in the hollow and an assistant watches until the alloy is in a state of fluidity, adding at that moment the bits of cadmium or spelter. The operator now slightly tilts the coal so that the fluid alloy can pass through the channel into the form or mold. It is now finished and, by removing the cover, may be turned out and rolled thin enough to cut up into bits. When the rolling is in process the metal must be watched and as soon as it shows signs of cracking it must be annealed; avoid heating it beyond a cherry red, whereupon it must be rolled out as quickly as can be.—Emil Hinder of Pforzheim in the Deutsche Goldschmiede Zeitung.

RESISTANCE OF RAILWAY TRAINS.

AN author in Zeit. des Oester. Ing. Ver. after having reviewed the trials of M. F. Barbier on the Northern Railway of France on the resistance of trains, gives the results of other independent tests of the same kind to secure similar data regarding Austrian rolling stock, says a writer in Machinery. The result of these experiments has been presented in the same form as those of Mr. Barbier, and the formula derived is $R = a + bV + cV^2$, in which R is the resistance of the car in kilogrammes per ton of material, V the speed in kilometers per hour, and a, b, and c constants which are then reduced to a graphic formula where the several factors are set forth.

These tests were not made by means of indicators and dynamometers, but by observing the speeds and accelerations which the vehicles attained upon different grades, a speed that amounted to from 36 to 48 miles an hour, and sometimes held this for a comparatively long time. In the matter of cars at least 323 trains were used whose weight, length and composition were varied to correspond with the condition of actual service.

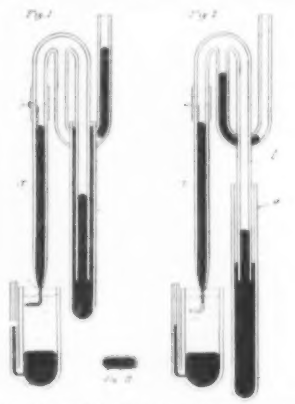
The author also notes the difference between this method of testing and the dynamometer method, of which he has made no use. He also gives the principal dimensions of the vehicles used and the curves obtained, not only by himself but by Leitzmann, Wittenberg, Clark, and others in former researches. Among other formulæ given are $R = 3.8 + 0.025V + 0.001V^2$ (between 24 and 48 miles an hour) for a 4-4-0 compound locomotive weighing 55.6 tons and having a six-wheeled tender weighing 36.7 tons in working order, attached; and $R = 1.6 + 0.184V + 0.00046V^2$ for four-wheeled cars weighing from 11 to 15 tons.

In conclusion, M. Sauzin summarizes the numerous influences which tend to modify the resistances of trains, such as wind, exposed areas, lubrication, temperature, etc.

THE ORLING-ARMSTRONG ELECTRO-CAPILLARY RECORDER.

By the English Correspondent of the SCIENTIFIC AMERICAN.

SOME two years ago we described in the pages of the SCIENTIFIC AMERICAN the new electro-capillary relay that had been invented by Messrs. Armstrong and Orling, of London, for utilization with their new system of wireless telegraphy. The feature of this device is its extreme simplicity, combined with a high degree



METHODS OF ADJUSTING NORMAL POSITION OF THE MENISCUS.

of sensitiveness which renders it especially applicable to those purposes for which a delicate apparatus is requisite, and which conditions are not fulfilled with the present types of relay.

Since that time several considerable improvements have been carried out to render the device more perfect and its extent of utility has been considerably augmented. Its simple design has been retained and the essential parts thereof can be manufactured at a small expense, but its sensitiveness has been accentuated to much greater degree. Now it can be applied to long-distance land and submarine cable work with perfect efficiency and records signals by photographic agency.

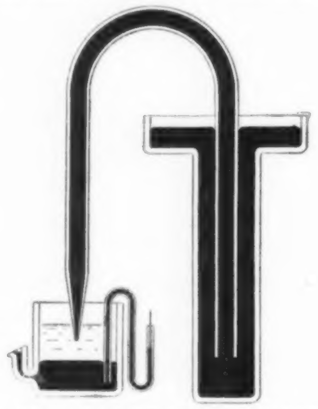
The principle of the relay is based upon the same as Lippmann's electrometer. The action is dependent upon the change of surface tension at the bounding surface between mercury and sulphuric acid when there is a difference of the potential created between the two liquids. The device consists of a capillary tube containing the mercury and the foregoing change causes the mercury to flow out of the tube thereby closing the electric circuit. The difference between the relay and the recorder, however, is that the mercury never flows out of the tube but rises and falls within it according to the difference in potential.

The mercury is contained in the column *T*, Fig. 1, and this tube, as will be seen, terminates in a fine capillary extension bent at right angles and carried beneath the surface of the dilute sulphuric acid. The bounding surface between these two media is at the center of the horizontal section of the capillary portion. There is a fine platinum wire fused into the glass to establish connection with the mercury, while the connection with the electrolyte is obtained by means of a quantity of mercury. When a potential difference is set up between the two terminals the end of the fine thread of mercury approaches or recedes from the aperture of the tube according to the polarity employed, and by the use of a projection apparatus the magnified image of the thread is recorded upon a traveling sensitized tape. The other tubes which may be seen in the diagrams serve for the purposes of adjusting the position of the mercury thread in the capillary tube. One very important feature of this device

ELECTRO-CAPILLARY TELEGRAPHIC RELAY OF THE ORLING-ARMSTRONG SYSTEM.

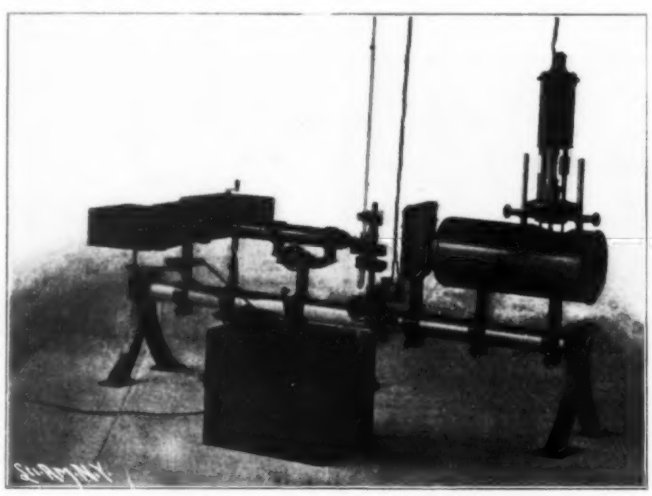
is that once the adjustment is made—an operation that can be carried out quickly and easily—it remains constant, the end of the thread of mercury returning to the zero position with absolute certainty immediately upon the removal of the potential difference.

The most salient characteristic of this invention is the infinitesimal amount of current that is required to operate it. Practically no current flows through it, the action being entirely attributable to the polarization at the surface of the electrolyte. For working purposes one-third of a volt, working through a megohm, is adequate. It is in this remarkably low consumption of current that the apparatus is of such value in connection with submarine cable work as it fulfills all the requirements of a siphon recorder and can be operated twice as quickly. Owing to its high sensibility, therefore, only a low battery power is necessary, a very important consideration, concerning its appli-



THE ORLING-ARMSTRONG DROPPING ELECTRODE.

cation to submarine cable work, and the invention marks a decidedly progressive step in connection with this ramification of telegraphy; for, ever since the laying of the first transatlantic cable, repeated efforts have been made to increase the speed of signaling. These attempts, however, have not been attended with conspicuous success owing to the inherent difficulties



THE ORLING-ARMSTRONG CAPILLARY RECORDER AS USED WHEN ARTIFICIAL LIGHT IS EMPLOYED.

Complete with electric arc light, light-tight box containing photographic tape and motor for driving the drum of the latter.

of retardation which have militated against the transmission of the necessary current impulses of sufficient strength.

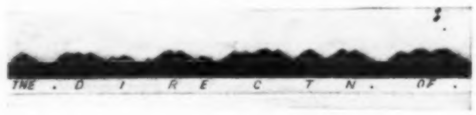
This retardation, as is well known, is due to the high electrostatic capacity of the cable, so that it has to be charged before a corresponding potential differ-

ELECTRO-CAPILLARY RECEIVER OF THE ORLING-ARMSTRONG SYSTEM.

ence can be set up at the distant end, and the longer the cable the greater the length of time required to charge it, owing to increased capacity. Under these circumstances it is obvious that the smaller the potential difference required the sooner will the cable be charged and the signals transmitted, and the more readily the receiving instrument employed is actuated the shorter will be the time during which the potential difference must be maintained. Therefore in order to attain a high speed of signaling, low potential impulses must be employed, and in order that the potential may be as low and the length of time during which it is applied as short as possible, the receiving instruments must be of a highly sensitive character. These conditions are fulfilled with the Orling-Armstrong electro-capillary recorder. There are no coils and consequently no impedance and practically no resistance is offered, while the weight of the moving fine thread of mercury is practically negligible.

When the signals are received the tension of one of the surfaces of contact is instantly varied, causing the

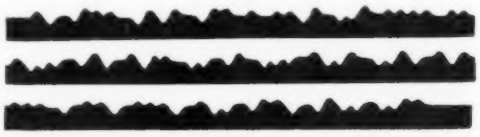
REVERSALS SENT AT THE RATE OF 110 AND 120 WORDS A MINUTE.



A SPECIMEN OF MESSAGE RECEIVED BY THE ORLING-ARMSTRONG RECORDER.

fluids to rise and fall in the tube according to the nature of such signals. There is a beam of light associated with this tube which normally falls upon a traveling photographic tape. When, however, signals are received, this beam is more or less screened by the movement of the opaque fluid thereby enabling a photographic record to be obtained.

This recorder responds to extremely small differences of potential owing to the small mass of the moving part whose movements are recorded on the tape and the consequent small inertia to be overcome. On the other hand the operation of the siphon recorder now so widely used for long cables, depends on the polarity imparted to a suspended coil, by the current received through the cable, which causes it to move in a stationary field and to so produce a record on a tape. This coil being several hundred times heavier than the moving part in the capillary recorder, offers considerable mechanical resistance to the small force that is to move it; furthermore, the suspended coil has normally a very slow natural period, which must be in beat with the received signals if interference between



FAC-SIMILE OF A MESSAGE.

the swing of the coil and the impulses which are to actuate it is to be avoided. To enable acceleration in the receiving of signals possible, the period of the coil would have to be further quickened by increasing the tension of its suspension. But this would necessitate a further strengthening of the transmitted signals, and against this must be placed the effect of retardation, which is greater when strong impulses are transmitted. Therefore it is apparent that stronger impulses could not be transmitted so rapidly, which demonstrates that the speed limit of reception by the present coil instrument has been attained.

Electrical energy is transmitted along a conductor with a velocity approximating that of light; but although some of the energy reaches the distant end of the cable almost instantaneously, the major part of it is consumed in charging the cable, and some time

elapses before a sufficient potential difference is built up at the distant end to operate the receiving instrument. It then takes time to discharge the cable. Therefore the more sensitive the receiver is to small changes of potential, the more suitable is such a receiver for long submarine cables where high efficiency is required. On the other hand, it is maintained by some authorities that if a receiver is employed which is too sensitive, it would be too readily affected by extraneous influences, and record unintelligible signals. Such is indubitably the case with a slow-working recorder, whose curved recorder line has its signals comparatively far apart; but as the Orling-Armstrong capillary recorder permits of a very high speed, the curves due to ordinary disturbances do not seriously affect the legibility of the actual signals. Furthermore, owing to the low potential of the impulses used, the loss by leakage is practically avoided.

From the tests and operations that have been carried out with the electro-capillary recorder, it is peculiarly adapted for cable work, as the speed of the messages received by means of this instrument has been twice as fast as by any other type of apparatus. Successful results have also been attained when used in connection with land lines, and it has been proved that leakages are to all intents and purposes overcome, and it can be equally well employed with underground and with overhead cables, notwithstanding the greater percentage of retardation in the former as compared with the latter. Nor has its application to wireless telegraphy been overlooked, and it is especially useful in this branch of telegraphic communication. It enables the speed of transmission to be greatly increased, and more feeble electric impulses may be received than by any other means, while the operation of the kumascope is rendered more certain. When used for wireless telegraphy, the recorder is used in series with an ordinary coherer. The special feature of this application is that when practically no current is permitted to pass through the coherer, the latter self-decoheres. Consequently, Morse signals can be recorded with the same ease as when telegraphed through wires. Two other important advantages possible are that shorter antennæ can be employed and greater distances covered, while reliability in operation and syntonic working is assured.

In our seventh illustration the capillary recorder is shown complete with the projecting apparatus, a light-tight inclosed box containing the revolving drum of sensitized photographic tape, together with the motor for driving the mechanism attached. In this illustration the artificial light utilized is the ordinary electric arc, but a Nernst lamp is now used in this particular installation. Other illuminants may be employed with equal success, such as oxyhydrogen or acetylene gas. Also if the conditions permit, the light-tight box can be dispensed with. Instead the tape may be exposed through a narrow orifice provided in the wall of an ordinary dark room. This permits of the tape being developed and fixed as rapidly and continuously as the photographic record is made.

Several highly successful and remarkable results have been made with this apparatus during the course of numerous tests. It has been employed upon the telegraphic line between London and Glasgow, a distance of 400 miles, over mixed underground and overhead cables, recording messages transmitted by the Wheatstone transmitter at the rate of 360 words per minute. Communication has also been established between London and New York without the assistance of any intermediate relay or repetition of the messages. Another feature of the apparatus is that a large number of recorders can be connected in parallel without interfering with their efficient operation. Over land lines, parts of which were underground, 360 words a minute have been sent with a megohm or 1,000 ohms in the circuit. The same rate of speed has been attained on an iron wire line of 4,000 miles.

From the results of the demonstrations that have been brought to such a highly successful issue by the application of this apparatus, the electro-capillary recorder opens up new possibilities in the work of telegraphic communication, as well as for other purposes, such as steering torpedoes, firing mines, standard measuring instruments.

MINES AND SUBTERRANEAN TORPEDOES AT PORT ARTHUR.

BEFORE the Japanese hoisted the flag of the Rising Sun upon the ruins of Port Arthur, how many of their brave soldiers fell upon the glacis of the forts, not always killed by the rifles or guns of the defenders, but often by the explosion of mines and subterranean torpedoes that the Russians planted at the approaches to their work? For now, just as in former times, despite the progress of artillery in range and power, it is necessary, in war and siege, to finish by storming, and the last defenses are the most bloody.

Toward the end of the nineteenth century, it really seemed as if there would be less and less recourse to methods that appeared to be so superannuated. Brantome mentions mines in 1600, and lo and behold! the most ancient processes reappear upon the threshold of the twentieth century. Is not a shield used for the infantry in all armies? What are, then, these mines and these subterranean torpedoes?

A subterranean mine is one so arranged that it shall burst under the tread of an assailant and project earth and pieces of rock into the air. Sometimes it projects stones arranged in advance, and is then called a stone mine. The terrestrial, like the stationary or floating marine torpedo, is a closed apparatus. It is placed close to the surface of the earth, is operated by a very simple mechanism, and is exploded at the will of the defender, or automatically at the passage of the assailant.

While the mine is generally charged with ordinary powder, explosive powders are employed for the torpedo, since the latter is, upon the whole, merely a large projectile sunk in the immediate vicinity of the works.

The mine, in fact, placed at a certain depth, must cause an uplifting of the earth, a projection in all directions, and an excavation called a funnel. The explosion must be progressive like that of a cartridge

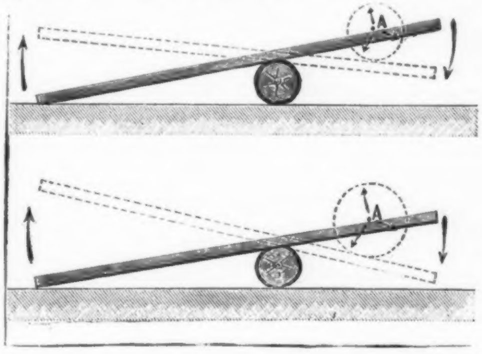


FIG. 1.—EXPERIMENT ON THE EFFECTS OF SLOW AND QUICK POWDER.

in the chamber of a gun, and hence the use of slow powder, mine powder or gunpowder.

The torpedo, the upper part of which is on a level with the surface, must produce the effect of a projectile. It must burst its jacket and instantaneously project a large number of fragments. A well-known comparative experiment shows the difference in effects of a slow powder and an explosive or quick one. If we place a plank upon a roller (Fig. 1), and arrange small charges of gunpowder and melinite successively upon the projecting part, *A*, what will occur will be this: When the gunpowder explodes, the plank will be lifted and see-saw upon the roller. The explosion of the melinite, on the contrary, will break off short the overhanging part, while the long end of the plank will remain immovable. The powder gas has an elastic effect, while that of the melinite, developing instantaneously, has a breaking one.

How are these two engines that have caused the Japanese so many losses arranged? The ordinary mine is placed at the bottom of a shallow excavation which is afterward filled in with earth and fragments of rock. The stone mine has the structure of a projection weapon (Fig. 2). It is excavated obliquely, so that it may project its contents in the direction of the slope that the assailants have to climb, and the powder is covered with a board loaded with stones. The whole is covered with a thin stratum of earth so as to conceal its location. These two engines are in communication with the interior defenses of the work through an electric conductor that permits of firing them, or even simply through a fuse, saucisson, etc.

The subterranean torpedo consists of a strong box containing the explosive powder. It is sometimes exploded at will by the defenders, and sometimes, as was generally the case at Port Arthur, by the assailants themselves, who, in treading upon the surface beneath which the torpedo is perfectly concealed, establish an electric contact (Fig. 3), or pull the wire of an exploder (Fig. 4), and thus cause the torpedo to burst

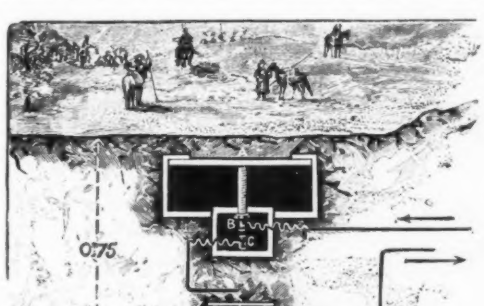


FIG. 3.—TYPE OF ELECTRIC AUTOMATIC TORPEDO.
A. Board supported by a spring. B C. Terminals. D. Electric exploder. E. Charge of explosive powder in a strong box.

directly under them. To these two simple systems of automatism, it is evidently possible to add others, such as an abrupt admixture of sulphuric acid and chlorate of potash, etc.

In certain sieges of the last century, which were pushed to the very last limits, the defenders prevented the assailants from entering the moats and breaches, at the moment of the assault, by means that were completely analogous. They prepared loaded bombs and fulminating barrels, which they buried at the foot of the breach or made ready for rolling down from the top of what remained of the ramparts upon the assailants clambering over the ruins of the scarp.

A terrible reminiscence, borrowed from the history of the sieges of the Peninsula, will make the work of these engines of destruction understood. It relates to the siege of Badajoz in 1814, which was defended by the heroic Rey against the Duke of Wellington.

On the 4th of April, the breaches of the bastions of Santa Maria and Trinidad were accessible, but the English had neglected to make any preparations for descending the high counterscarp and afterward attacking the breaches. Col. Lamarre took advantage of this. In the moat, under a thin stratum of earth, he arranged a string of sixty bombs which could be fired

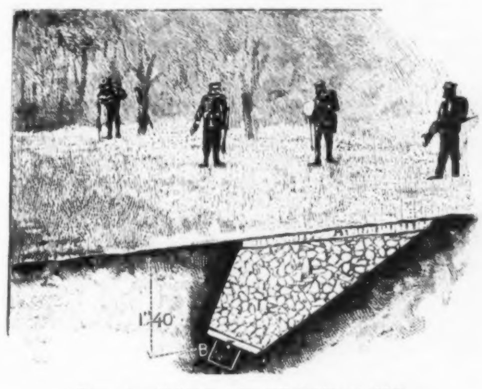


FIG. 2.—TYPE OF STONE MINE.
A. Layer of earth. B. Charge of ordinary powder.

simultaneously from the rampart through the intermedium of a saucisson protected by hollow tiles.

The assault took place before daybreak on the 6th of April. The English threw themselves into the moat, where they were illuminated by the fusillade. The bombs were fired and, upon exploding, caused great carnage. The English redoubled their efforts, and then, although strengthened by reinforcements, began to hesitate. Finally, urged on by their officers, they rushed forward and attacked the breaches. But here they were thrown into confusion by grape-shot from the bastion guns of Trinidad and by the bombs and fulminating barrels that were rolled down upon them. The carnage was frightful. The moat was like a volcano, and the explosion of the bombs and fulminating barrels made the earth tremble with a terrific noise. Flashes of flames brighter than the light of day suddenly followed by pitchy darkness increased still further, in the eyes of the assailants, the dangers of this scene of horror.

Assembled in groups and resting upon the barrels of their guns, the English contemplated the bastion of Trinidad with deep despair, while their enemies, showing themselves upon the ramparts, and gazing at their victims by the light of the explosions, exclaimed, upon seeing them fall: "Why didn't you enter Badajoz?" In the midst of this terrible situation, the dead accumulated in piles, the wounded crawled away to seek protection against the galling fire of their merciless adversaries, and stomachs were sickened by the odor of the burning flesh of the cadavers.—Translated from La Nature for the SCIENTIFIC AMERICAN SUPPLEMENT.

CONTEMPORARY ELECTRICAL SCIENCE.*

N-RAYS.—E. Salvioni gives an account of a laborious series of experiments made for the purpose of testing Blondlot's N-ray observations. As a general result, he is of opinion that there is some objective reality

FIG. 4.—TYPE OF MECHANICAL AUTOMATIC TORPEDO.
A. Board movable around the axis *a*. B. Exploder attached by a wire to the board A. C. Charge of explosive powder.

of the phenomena mixed up with a number of subjective elements. He is driven to this conclusion by the extreme clearness with which he observed a few of the appearances, such as the effect upon a line of calcium sulphide, and the maxima and minima from which Blondlot deduced the wave-length of the rays. On the other hand, he has failed in obtaining positive results by any of Blondlot's "objective methods," and has found that physiological and psychological elements have a considerable influence. Both he and his assistants worked themselves into a state in which

* Compiled by E. E. Fournier d'Albe in the Electrician.

a bewildering variety of luminosities appeared to them, but found that a few months' rest left them in a state less fit than ever to obtain positive results. The author points out that the phenomena, especially on the medical side, show a suspicious resemblance to "animal magnetism," though such resemblance should, of course,' not prejudice truly impartial investigators.—E. Salvioni, Nuovo Cimento, August, 1904.

CONDUCTIVITY OF RADIUM BROMIDE SOLUTIONS.—F. Kohlrausch and F. Henning have experimented with radium bromide as an electrolyte, expecting that, either in consequence of its high atomic weight or its ionizing action, it might show peculiar effects. This expectation was, however, not realized, since the salt was found to be quite normal as an electrolyte, and to take its place in the ordinary series of related elements. This is another instance of the rule that in the behavior of the elements toward water the atomic weight plays no dominant part. The ionic mobility in water is 57 for radium, 56 for barium, and 53 for strontium or calcium. The temperature coefficient has also a normal value. The authors assumed Curie's value 225 of the atomic weight as a basis for their calculations. With Runge and Precht's value 258, the mobility would be 67. But even then it would be of the order of mobility of metallic ions.—Kohlrausch and Henning, Verhandlungen der Deutschen Physikalischen Gesellschaft, VI., No. 5, 1904.

MAGNETIC DEFLECTION OF IONIC CURRENT.—McClelland has shown that the space surrounding an incandescent platinum wire conducts electricity. This conduction is a complicated effect, being partly due to the ionization of the gas and partly to the projection of electrons from the wire. Gwilym Owen has simplified the conditions by heating the wire to a temperature not exceeding 200 deg. To determine the ratio e/m for the particles given off he employed Thomson's method of retardation of discharge by a magnetic field which involves the use of electric and magnetic fields at right angles to each other. His results are as follows: The current of negative electricity from a hot platinum wire at low pressures is mainly carried by corpuscles, the proportion of corpuscles to heavy particles being at least four to one. From 10 to 20 per cent of the discharge from uncleaned wire newly set up and also from a wire which has been cleaned by boiling in nitric acid is carried by heavy particles. By prolonged heating of the wire and frequently renewing the air in the apparatus the wire can be brought to such a state that the proportion of heavy particles in the discharge is only about 5 per cent even at very high temperatures. At low temperatures, even for wires that have not been subjected to prolonged heating, the discharge is wholly carried by corpuscles. The value of e/m for these corpuscles was found to be 1.41×10^7. The magnitude of the discharge after various treatments of the wire suggests that the discharge is due primarily to the ionization of gases (probably hydrogen) occluded in the wire. This confirms the result obtained by H. A. Wilson. The author believes that the disintegration of the metal is due to the carrying away of particles of the metal by the gas as it escapes, and these particles convey a small portion of the discharge.—Gwilym Owen, Proceedings of the Cambridge Philosophical Society, 12, Part 6, 1904.

VERTICAL-FORCE MAGNETOGRAPH.—W. Watson describes a new quartz-thread vertical-force magnetograph which offers a simple compensation for temperature and also eliminates the knife-edge, thus preventing the irregularities produced by dust on the supporting plane. In principle the instrument resembles the quartz-thread gravity balance designed by Threlfall. The instrument consists essentially of a magnet suspended on a horizontal quartz fiber which is kept stretched by means of a quartz spring. The center of gravity of the magnet and the torsion of the fiber are so adjusted that the axis of the magnet is horizontal. The balance of the magnet is so adjusted that the center of gravity lies on the same side of the axis of the fiber as the south pole, the displacement being such that, to make the magnet lie with its axis horizontal, the fiber has to be twisted in the anti-clockwise direction. In this case, when the temperature rises, the north end of the magnet will tend to rise, owing to the decrease in magnetic moment, but will tend to fall owing to the increase in the stiffness of the fiber. Thus, by suitably adjusting the horizontal displacement of the center of gravity of the magnet—that is, the initial torsion of the fiber—matters can be so arranged that the decrease in the couple due to the one effect is exactly equal to the increase due to the other; and so, changes of temperature do not affect the position of the magnet. In the instrument described, the horizontal displacement of the center of gravity is effected by moving a small weight along the magnet, and the possibility of obtaining complete compensation depends on the fact that the coefficient of increase of the rigidity of the fiber is much greater than the coefficient of linear expansion of steel.—W. Watson, Terrestrial Magnetism, June, 1904.

WIRELESS TELEGRAPHY.—J. Zenneck discusses recent theoretical work in wireless telegraphy with a view to the practical application of its results. The difficulty of obtaining an agreement between the theoretical and actual frequencies of a transmitter lies in the unavoidable presence of wire ropes near the antenna, a difficulty which is increased tenfold on board men-of-war. But though it may be impracticable to calculate the frequency, the resonance method devised by Bjerknes enables us to measure it with ease and rapidity. As regards the merits of multiple antennæ, the author remarks that a multiple antenna has the same effect upon the wave-length as a single antenna of increased thickness but without as much increase of weight. For equal lengths, a capacity of a multiple antenna is greater than that of a single antenna. Besides, the ratio of energy radiated to energy supplied is greater, so that multiple antennæ have a greater efficiency. The primary circuit of the Tesla transformer should have a high capacity and low inductance. It is best to let the primary circuit consist of a single turn of wire or several turns in parallel. The author differs from Drude as to the degree of coupling giving a maximum amplitude. Drude puts it at 0.6, but the author has obtained a maximum at 0.18, being a much looser connection. As regards the primary spark potential, the author shows that the maximum amplitude in the secondary system rapidly increases with the primary E.M.F. up to a sparking distance of about 4 centimeters. In cases where the damping factor is to be determined, the method of Bjerknes has been found to work well. It is advisable to vary, not the inductance, but the capacity of the resonating circuit, and to measure the current by means of a bolometer affected by induction. The method yields the damping of the primary and secondary systems and the frequency of one system, when the frequency of the other is known, with sufficient accuracy.—J. Zenneck, Physikalische Zeitschrift, October 1, 1904.

SOME REFINEMENTS OF MECHANICAL SCIENCE.*

By AMBROSE SWASEY.

FOR the subject of my address I wish to speak of a few of those methods and mechanisms which have been developed and perfected to such a degree of refinement that they may be considered as almost beyond the practical, and yet were it not for such refinements they could not possibly be made to serve the utilitarian purposes which make them of such inestimable value to us all.

The division and the measurement of time is to-day, as it has been for ages, among the most important of the subjects affecting the welfare of mankind, and as time has rolled on and there has been a better understanding of the laws governing the universe, nearer and nearer has been the approach to perfection in the working out of these difficult problems, but the many limitations surrounding them have always kept their full solution somewhere in the future.

The diurnal revolution of the earth, which gives the solar day, and the revolution of the earth around the sun, the solar year, are the arbitrary divisions of time marked off with the utmost precision by the celestial bodies; and while the length of the solar day has, from before the Christian era, been fairly well defined, the length of the solar year was but approximately known until within a few hundred years.

The length of the year, as counted by the Julian calendar, was too long by 11 minutes and 14 seconds, and this error amounted to 10 full days in the 1,600 years from the time the Julian calendar went into effect until the introduction of the Gregorian calendar.

A few years ago, when visiting the Vatican Observatory, I was particularly interested in the Gregorian Tower, which forms a part of the Vatican Library building. After passing through a number of rooms which are used in connection with the observatory, when near the top of the tower, I was taken into the spacious and beautiful calendar room, the walls of which are covered with paintings of the highest order, executed centuries ago, under the direction of Pope Gregory XIII. In the center of the room, and forming a part of the floor, there was a large marble slab, on which was cut a fine line exactly in the true meridian, and upon the line was a special mark which indicated the altitude of the sun at noon of a certain day. On the south wall, near the top of the room, there was a small aperture through which the direct rays of the sun passed at noon, projecting a bright spot on the meridian line.

All of this had been planned and executed by the astronomers in order that they might demonstrate the necessity of reforming the calendar, and when at noon on the 23d of March, 1582, Pope Gregory saw that the altitude of the sun as shown by the beam of light, was not for that particular day, but for the day 10 days previous, he directed that 10 days be stricken from the calendar, and that day should be the 11th of March, instead of the 23d.

With such precision had the astronomers determined the true length of the year, that our present calendar with its intercalations will continue on for 20,000 years, with an error not to exceed a single day.

The line on the marble slab and the aperture through the wall of the calendar room were devices simple in the extreme, and in this day of instruments such a method would hardly be considered, yet they served their purposes admirably, and the placing of that line on the true meridian, with an accuracy never before attained, was considered one of the greatest scientific achievements of that age.

Since an unknown time the day has been divided into 24 hours, and as civilization has advanced, the greater has been the necessity for the utmost precision in the measurement of each hour, with its sub-divisions.

The sun dial is not only the earliest, but the most interesting of all the numerous arrangements that have been devised for measuring the divisions of the day. Notwithstanding its limitations, it has been a subject which has attracted the brightest minds for ages. Within these later years there has been a renewed interest in this ancient time-keeper, not only in copying the types of dials, which are valuable because of their antiquity, but in working out new forms. Recently a new dial has been invented, by which the rays of the sun will indicate the true mean time for each day of the year, with an error not to exceed one minute.

The hour-glass, which came later, was considered a much more practical method, inasmuch as it could be used either day or night, and because its use was not confined to a particular location; however, as a timekeeper it was not satisfactory, even in those early days.

The clepsydra or water clock, which is supposed to have been invented by the Greeks, was found to be a much better timekeeper than either the sun dial or hour-glass, and it was a great step in advance toward the accurate measurement of time.

These water clocks are to this day used extensively in the East, more especially in China. Those first used by the Greeks consisted of two water jars so arranged that the water from the upper ran into the lower, and the time of day was determined by measuring the depth of water in the upper jar, and at sunrise each day the water was returned to the upper jar. In the city of Canton there is a water clock which has been running for 800 years, and at the present time it is the standard clock of that city.

This clock consists of four water jars, each having a capacity of eight or ten gallons. The jars are placed one above the other, in the form of a terrace, the three upper ones being provided with a small orifice near the bottom, through which the water drops into the jar next below, and so on down from one to the other, until the water reaches the lowest or registering jar. In this there is a float, to which is attached an upright, having graduations for the hours and parts of hours, and as the water rises the time can be determined by noting the height of the float in relation to the cross-bar at the top of the jar.

In this improved form of water clock the variation in the flow of water due to the difference in height is overcome by having a series of jars, the outlet of the upper being so graduated that there is but little variation in the height of water in the second jar, and in the third the height remains practically uniform, thus insuring a constant head for the water which drops into the registering jar. At the beginning of each day the water is taken from below and carried up a flight of steps to the top.

That such an arrangement has some elements favorable to the accurate measurement of time, there can be no doubt. It certainly has the element of simplicity, and notwithstanding its long service, the only wear noticeable was confined to the steps leading to the upper jar.

Clocks of the present type, although used as far back as the twelfth century, and possibly earlier, were but fair timekeepers, until several centuries later. Those which the astronomers used in their observatories at the end of the fifteenth century were so unreliable that modified forms of the clepsydra of the ancients were used, and as they did not prove to be satisfactory, most of the observations were made without the use of clocks.

Galileo's beautiful discovery of the isochronism of the pendulum from the swinging chandelier in the church at Pisa was of great value in many respects, but in none more so than in its application to the measurement of time.

Soon after that great discovery the English clockmaker, Graham, invented the mercurial pendulum, by which the variation in its length caused by the difference in temperature was fully compensated, and some years later Harrison, another English clockmaker, invented a compensating pendulum, which consisted of a series of metal bars having different coefficients of expansion—so that 200 years ago, as it is to-day, the pendulum was the nearest perfect of all the devices that have been employed for governing or controlling the motions of a clock mechanism.

Every part of the clock, down to the minutest detail, has been the subject of study and improvement, and they are made and adjusted with such precision and delicacy that in testing them the question is, Within how small a fraction of a second will they run? Not content with their marvelous performance when under normal conditions, some of the finest astronomical clocks are surrounded by glass or metal cases, within which a partial vacuum is maintained, and in order that the cases may not be opened or disturbed, the winding is done automatically by means of electricity, the frequency of the winding in some cases being as often as once every minute. These clocks are set up in especially constructed rooms or underground vaults, where they are free from jar or vibration, where the temperature and barometric conditions remain practically constant, and where every possible precaution is taken to further minimize the errors of the running rate. A clock in the observatory at Berlin has run for several months, under these favorable conditions, with a rate having a mean error of but fifteen one-thousandths of a second per day and a maximum error of but thirty one-thousands of a second per day.

Another clock installed at the observatory of Case School of Applied Science, at Cleveland, running under similar conditions, also has a mean error of fifteen

* Presidential address at the New York meeting of the American Society of Mechanical Engineers.

one-thousandths of a second per day, with a maximum error for several months of but twenty-two one-thousandths of a second per day.

These are notable examples of the present state of the art of clockmaking, and show the wonderful precision with which minute intervals of time can be measured.

From the time of the invention of Peter Hele, in 1477, of the "Nuremberg animated egg," or "pocket clock," which required winding twice a day, and varied an hour and a half in the same length of time, the development of the watch has kept pace with the "mother clock," and followed closely to it in time-keeping qualities.

These marvelous little machines, whether made at the homes of the peasants among the hills and mountains of Switzerland, where the skill required for making a single part has been handed down from generation to generation, or made in the great factories of this country, where fully 2,000,000 high-grade movements are turned out annually, and where the skill of the workmen has been supplemented by modern methods and machinery, are, notwithstanding the difficulties attending their manufacture, produced so cheaply as to be within the reach of almost everyone.

The larger watch, or ship chronometer, with its escapement so delicately made and adjusted that it must always be kept in the same position, was greatly improved through the efforts of the British government in 1714 by offering rewards of 10, 15 and 20 thousand pounds to any who should make chronometers that would run so accurately that the longitude of a ship at sea could be determined within 60, 40 and 30 miles; and Harrison, the inventor of the compensating pendulum and the compensating balance, which is now used in watches, succeeded in making a chronometer, which, after being tested on a long voyage, was found to run so closely that the position of the ship was determined within 18 miles, and he was therefore paid the full award of 20,000 pounds. The historic chronometer, which marked a new era in navigation, is now numbered among the treasures of the Greenwich Observatory.

Modern ships are equipped with chronometers so accurate and so reliable, and with sextants of such precision that navigators can determine their position in latitude and longitude within a few miles. Therefore, with the increased speed of the powerful ships carrying hundreds or even thousands of passengers, together with their valuable cargoes, the methods and instruments used in navigation have been so improved as to greatly diminish the dangers in crossing the seas.

The perfection attained in the measurement of time, which is of such great practical value in nearly every sphere of life, would not have been possible were it not for the even greater refinements that have characterized the methods and instruments used by the astronomer in determining the length of the day and of the year, which are the fundamental standards of time.

The division of the circle and the measurement of angles have ever been among the unsolved problems of the astronomer, yet in the instruments used by him, circles have formed a most important part.

Long before the telescope was invented, Tycho Brahe, the Danish astronomer, "the founder of modern astronomy," constructed for his observatory instruments of various kinds having graduated circles and arcs of circles. His instruments for the most part were improvements on those used by Arabian astronomers in the eighth and ninth centuries, and these, in turn, were copied after similar instruments used by the Greeks and Egyptians a thousand years previous, and it is supposed that such instruments were used by the Chinese at an even earlier period, so that graduated circles have come down to us from the far-off ages.

The longer the radius the more accurate the graduations, was the principle upon which the early instruments were made. The Arabians, in about the year 1000, built a sextant with a 60-foot radius and a quadrant with a 21-foot radius, but to Tycho Brahe is due the credit of constructing instruments having circles much smaller in diameter and graduated with a greater precision than ever before. It was by the use of such improved instruments of his own making, and by his observations, which were made without a telescope or any means of magnification, that he was able to give the positions of a large number of stars within less than one minute of arc from the positions given by modern astronomers.

The graduation of an eight-foot mural circle in 1725 by Graham, of England, for the National Observatory, and of an eight-foot quadrant by Bird, in 1767, were notable steps in advance in the division of the circle and the measurement of angles, but these and similar instruments, although their efficiency was greatly augmented by the use of the telescope, have been supplanted by others more practical.

The first circular dividing engine was made in 1740 by Henry Hindley, of New York, for cutting the teeth of clock wheels, and it is interesting to note that in the same year Huntsmann, another clockmaker of Sheffield, invented the process of making crucible steel, that he might have a metal suitable for the springs of his clocks.

Of the several engines constructed later, the one most successful and representing the greatest progress, was that made by Ramsden in 1777. This engine, automatic in its movements, was made especially for graduating circles, and because of the great precision with which he divided the circles of the instruments used by the government, the Board of Longitude awarded him the sum of 615 pounds. A further and most potent recognition of the excellence of his work lies in the fact that all subsequent circular-dividing engines have followed closely the same general principles of construction embodied in the Ramsden engine.

It is most gratifying to all those who are interested in mechanical progress that the Ramsden engine has been preserved throughout all these years, and it now stands in the museum of the Smithsonian Institution at Washington as a monument to the one who made it and as the best example of that time of the art of graduating circles.

Many excellent dividing engines have been made that are quite sufficient in point of accuracy for the work for which they were intended, but the perfection required in the graduation of circles for astronomical instruments is such that it has been found to be one of the most difficult of all mechanical problems to make an engine that will meet such requirements.

In such an engine the chief essential is that the spindle carrying the master-plate shall be as nearly round and as closely fitted in its bearings as is possible, for the degree of excellence with which that work is done determines how closely a circle can be divided.

It seems almost incredible that a well-lubricated spindle of four inches in diameter at its largest part and tapering three-quarters of an inch to the foot can be made so nearly round and so closely fitted in its bearings that a movement of one-thousandth of an inch in or out of its bearings will in one case cause it to turn with difficulty, and in the other with perfect freedom, yet this has been found to be within the limits of mechanical refinements.

The greatest accuracy thus far attained in such engines is one second of arc, which arc, with a radius of three miles, equals one inch, and at 20 inches, which is the radius of the silver ring upon which the graduations on the master-plate are made, a line one-thousandth of an inch in width is equal to 12 seconds of arc, or 12 times the accumulated errors of any number of divisions, or 20 times the greatest error of any single division.

In automatically graduating a circle it has been found to be impracticable to cut more than six lines in a minute, and it requires about 33 hours to divide a circle into two-minute spaces. As with the running of the finest clocks, the best results can only be obtained when the engine is surrounded with every favorable condition possible. Instead of the large circles and sectors used by the ancients, they have been made smaller in diameter, as the methods for graduating have been improved, until those of the more modern instruments are seldom more than 30 inches, and some of the latest meridian instruments have circles of but 25 inches.

The smaller circles, which can be made and graduated with greater precision than the larger ones, are also less liable to change in form owing to their weight and the variation in temperature, and with the aid of the reading microscope the results obtained would not be possible with the larger circles.

A 25-inch circle read with a microscope having a power of 40, would be equivalent to a circle of about 80 feet in diameter, and a single second of arc as seen through the microscope would be equal to 0.0024 of an inch, a quantity easily subdivided.

A most important adjunct to the astronomer's instrumental equipment is the filar micrometer. With it he determines the errors of divisions, the eccentricity of his circle, and measures the angles to within a fraction of a second; and when used at the eye end of the telescope he determines the positions and motions of the stars and the distances and diameters of the planets. In these little instruments, whether of the simple or complex form, the chief requisites are the screw and the cross wires, for upon them the value of the observations and measurements depend.

To make the screw of a micrometer so true that the errors in the threads cannot be detected by its own magnifying power, is an extremely difficult task. These micrometer screws are often made with 100 threads to the inch, and are provided with graduated drums having 100 divisions, the readings being made in tenths of a division.

The cross wires, which are but common spider lines, because of their fineness and the remarkable qualities they possess, are indispensable in micrometric work.

That the repulsive and even dangerous spider has plenty of enemies among the human family, there can be no doubt, yet if the value of the contributions which it has made to the cause of science were generally known, it would surely have a greater number of friends than at present, and most certainly the astronomer will say naught against it, for, after the experience of many years, he has found that the spider furnishes the only thread which can be successfully used in carrying on his work.

The spider lines mostly used are from one-fifth to one-seventh of a thousandth of an inch in diameter, and, in addition to their strength and elasticity, they have the peculiar property of withstanding great changes of temperature; and often when measuring the sun spots, although the heat is so intense as to crack the lenses of the micrometer eyepiece, yet the spider lines are not in the least injured.

The threads of the silkworm, although of great value as a commercial product, are so coarse and rough compared with the silk of the spider that they cannot be used in such instruments.

Platinum wires are made sufficiently fine, and make most excellent cross wires for instruments where low magnifying powers are used, yet as the power increases they become rough and imperfect.

Spider lines, although but a fraction of a thousandth of an inch in diameter, are made up of several thousands of microscopic streams of fluid, which unite and form a single line, and it is because of this that they remain true and round under the highest magnifying power.

An instance of the durability of the spider lines is found at the Allegheny Observatory, where the same set of lines in the micrometer of the transit instrument has been in use since 1859.

The placing of the spider lines in the micrometer is a work of great delicacy, and in some micrometers there are as many as 30, which form a reticule, with lines two one-thousandths of an inch apart, and parallel with each other, under the highest magnifying power.

Step by step, from the methods of the Arabian astronomers to the time of Tycho Brahe and on down to the present day, improvements in the instruments and methods for the measurement of angles have been going on, until astronomers can measure double stars with a separation of one second of arc, and within less than one second they can define their positions in the heavens.

In the realm of the measurements of minute linear distances, and the perfection of curved and flat surfaces, the refinements are even greater than those pertaining to the measurement of time and of angles.

Most important in the linear dividing engine is the screw, and although much had been accomplished in bringing such engines to a high degree of excellence, it was for Prof. Rowland to make an engine which has a practically perfect screw; and without doubt it is in all respects the nearest perfect of all the mechanisms that have been employed for ruling lines exactly parallel and equally spaced.

The Rowland engine was made especially for ruling diffraction gratings, which are made of speculum metal, and with it a metal surface has been ruled with 160,000 lines, there being about 29,000 to the inch, and as many as 43,000 lines to the inch have been ruled.

The gratings mostly used have from 14,000 to 20,000 lines to the inch, and with such exactness is the cutting tool moved by the screw that the greatest error in the ruling does not exceed one-millionth of an inch.

The production of these gratings, which has enabled the physicist in his study of the spectrum to enter fields of research before unknown, has not only called for the highest degree of perfection ever attained in the spacing of linear distances, but it has also called for a refinement most difficult in the optical surfaces upon which the lines are ruled. To Mr. Brashear was given the problem of producing such surfaces, and, notwithstanding the many difficulties encountered in working and refining the speculum metal plates, he has made many hundred plates, with surfaces either flat or curved, with an error not to exceed one-tenth of a wave length of light, or one four-hundred-thousandth of an inch.

The established standards of length, which are the yard of Great Britain and the meter of France, being made of metal, and liable to destruction or damage, Prof. Michelson conceived the idea of determining the length of these standards in wave lengths of light, which would be a basis of value unalterable and indestructible.

For the purpose of carrying out these experiments the interferometer was constructed, an instrument which required the highest order of workmanship and the greatest skill of the optician. Again, Mr. Brashear proved to be equal to the occasion, and made for the instrument a series of refracting plates, the surfaces of which were flat within one-twentieth of a wave length of light, with sides parallel within one second. This was the most difficult work ever attempted in the refinement of optical surfaces.

Profs. Michelson and Morley devised a method for using the interferometer for making the wave length of some definite light an actual and practical standard of length. So satisfactory was the result that Prof. Michelson was invited to continue the experiments at the Bureau of Weights and Measures, at Sèvres, France, where the standard meter, which is kept in an underground vault and inspected only at long intervals, was used for that important work, which occupied nearly a year. The final result of the experiments shows that there are 1,553,164.5 wave lengths of red cadmium light in the French standard meter, at 15 deg. Centigrade. So great is the accuracy of these experiments that they can be repeated within one part in 2,000,000. Should the material standard of length be damaged or destroyed, the standard wave length of light will remain unaltered, as a basis from which an exact duplicate of the original standard can be made. These two marvelous instruments, the Rowland dividing engine and the Michelson interferometer, show the possibilities in the perfection of linear divisions and the standards of length.

We have recounted some steps of the progress that has been made in the measurement of time, of angles and of length, together with some of the refinements in these measurements, but we are confronted with the fact that, notwithstanding all that has been accomplished from centuries past down to the present time, as ever before, there are many imperfections requiring new problems in mechanical science to be worked out for the further enlightenment and welfare of mankind.

FROZEN MAMMOTH IN SIBERIA.*

By O. F. Herz.

[About the middle of April, 1901, the Imperial Academy of Sciences of St. Petersburg was informed by V. N. Skripitsin, governor of Yakutsk, of the discovery of a mammoth in an almost perfect state of preservation, frozen in the cliff along the river Beresovka, the right tributary of the river Kolyma, about 200 miles northeast of Sredne-Kolymsk, about 800 miles westward of Behring Strait, and some 60 miles within the Arctic Circle.

Thanks to the courtesy of Finance Minister Witte, 16,300 rubles were assigned for the prompt dispatch of an expedition to examine and secure this valuable find. O. F. Herz, a zoologist of the Imperial Academy of Sciences, was appointed chief of this expedition; E. V. Pfizenmeyer, zoological preparator of the same institution; and O. P. Sevastianoff, a geological student of the Yuryevck University, his assistants. The expedition started from St. Petersburg on May 3, 1901, and its chief reached the mammoth region on September 9.]

August 31-September 5.—After reaching Mysova we were unable to proceed directly to the mammoth region for three or four days because of the absence of the Cossack Yavlovski, who did not return until September 3. He informed us that serious illness had prevented him from visiting the mammoth region in the spring, and consequently the find had not been covered with earth and stones to prevent its injury by rain and beasts of prey. Unfortunately, the summer rains had washed a mass of earth down the slope in which the mammoth lies, and this had considerably damaged the hind part of the body. Wolves and bears had caused further injury to the head.

As I did not personally see the Lamut, S. Tarabykin, who discovered the mammoth, I can only give the story of the find as told me by Yavlovski. The Lamut, while deer hunting, was led to the discovery by finding a tusk a short distance above the real find. Upon the mammoth's head there was but one tusk, which the Lamut and two companions chopped out. As the latter afterward informed me, there was no trunk. At the end of August, 1900, all three repaired to Kolyma, where they sold the ivory to Yavlovski, telling him of the discovery. The Cossack, being an intelligent man, investigated the find personally, procured small portions of the body as evidence, and reported to the police commissioner, who in turn informed the governor of the matter.

September 11, 1901.—It was so warm to-day that the soil became loose and easily handled, and I was enabled to begin the work of excavation. The body lies in a cliff that faces east and extends for a mile in a semi-circle. The mammoth is about 67 yards back from the bank of the river. There is an upper stratum of earth, covered with moss. Beneath this is a mass of loam and earth mixed with stones, roots, pieces of wood, and lamellar plates of ice. Underneath this alluvial layer there is a vertical wall of ice, which stands free above the mammoth. Upon this supposed ice incline are huge shapeless masses of earth, evidently moved downward by the thawing of the ice as well as the water falling from the upper "tiaga" or marshy forest at the top of the cliff. According to natives, the head of the mammoth was exposed two years ago by the breaking away of a mass of earth; the rest of the body in August, 1900.

After taking some pictures, I began the excavation, and soon exposed the skull. To my great surprise I found well-preserved food fragments between the teeth, and this fact serves as proof that the animal died in this very position after a short death struggle. I found the marks made by the Lamuts in removing the left tusk, but I could find no traces of the right one.

At a depth of 27 inches we found the left fore-leg, still covered with hair up to the humerus, notwithstanding that the epidermis had completely rotted. In a frozen condition we may succeed in getting it to St. Petersburg. The hair appears to consist of a yellowish-brown under-coat 10 to 12 inches long with a thick, bristle-like upper coat, rust-brown in color, about 4 to 5 inches long. The left fore-leg is bent, so that it is evident that the mammoth tried to crawl out of the pit or crevice into which he probably fell, but apparently he was so badly injured by the fall that he could not free himself. Further excavation exposed the right hind-leg, which had become turned almost horizontally under the abdomen. Upon the left hind-leg I found portions of decayed flesh, in which the muscular bundles were easily discernible. The stench emitted by this extremity was almost unbearable.

LEFT FOREFOOT OF MAMMOTH.

September 12.—After we removed the earth from under the left leg, the thick underwool was exposed. Part fell out, but the remainder will be saved by bandages. The color may be described as roan. Five hoof-shaped blunt nails could also be seen at the end of the digits.

Considerable ice was found in uncovering the right fore leg, from which most of the hair was missing. The leg was so placed as to indicate that the mammoth after falling had supported himself on this leg while attempting to step forward with the left one. We concluded that he had died while in this position, and that he had by no means been washed there by water from elsewhere. The presence of the thick wool showed that the animal was well adapted to endure

SIDE VIEW OF THE MAMMOTH AFTER PARTIAL EXCAVATION.

* Extracts, translated for the Smithsonian Annual Report, from the diary of O. F. Herz, chief of the expedition of the Imperial Academy of Sciences of St. Petersburg to the River Beresovka for the excavation of the frozen mammoth.

cold. It is improbable that he died from hunger, for a large quantity of food was found in his stomach, which was similar to that found between his teeth.

September 14.—The mound was opened further south and southeastward, but no trace of the trunk was found. At a distance of about five inches from the upper edge of the sole of the right hind foot we found the tip of the tail. This tip is 9 inches long, with hairs 4 inches long, standing out in bunches around the end. The hair at the basal end is dirty yellow ocher in color, while further down it becomes much darker.

September 15.—I stopped further excavation until my companions, who were left behind, can arrive, and Mr. Sevastianoff can make the geological survey. In order to be able to dismember the mammoth after the severe cold weather sets in, I intend to build a structure over the animal that can be heated. Meanwhile I covered the body with tarpaulin to protect it from the weather.

September 17.—According to my opinion, the entire cliff rests upon a glacier which was disintegrating and in which there were deep crevices. The water that flowed down from the "tiaga" and from the neighboring hills, mixed with earth, stones, and pieces of wood, gradually filled these crevices. The whole was later covered with a layer of soil, upon which a rich flora doubtless developed, that served as excellent food for mammoths and other animals. Whether this flora is identical with the present flora will be known when the food fragments found in the mammoth can be examined.

September 19.—The timber for the building of a house over the mammoth is already cut and prepared.

Despite the fact that the carcass is in a frozen condition, the smell emitted is very disagreeable.

September 20.—At the exact hour of my prediction, Mr. Pfizenmeyer arrived with the rest of the transport equipment. Mr. Sevastianoff, however, was not with him.

September 30.—To-day we made the first experiments in heating the house, and the arrangement appears to be excellent.

October 2.—To-day in clearing away the earth from the occiput and back, we exposed several broken ribs and several lumbar vertebræ. Under the middle part of the abdomen we found yellowish-brown underwool 8 to 12 inches long.

October 3.—After removing the last layer of earth from the back, the remains of food in the stomach were exposed. The latter was badly decayed, while the other organs, exposed later, were practically destroyed.

October 4.—We removed the left shoulder blade and part of the ribs, and then cleaned part of the stomach, which contained an immense quantity of food remnants. In the afternoon we severed the left foreleg.

October 5.—To-day we skinned the left side and exposed several ribs, mostly well preserved. Then we skinned the head, of which parts were preserved. In the afternoon we removed the left shoulder, upon which we allowed the tendons and muscular fibers to remain. The flesh from under the shoulder, which is fibrous and marbled with fat, is dark red in color and looks as fresh as well-frozen beef or horse meat. The dogs cleaned up whatever mammoth flesh was thrown to them. The skin on the left shoulder is three-quarters inch thick, and on the right side nine-tenths inch thick.

The longest hair found came from the shoulders. It is ashy or pale blond in color, and is probably what has been erroneously called the mammoth mane.

October 6.—We bandaged the left fore-leg, packed it in hay and then wrapped it in sackcloth. Later these things will all be sewed up in skins.

We then amputated the right fore-leg above the shoulder, and removed the shoulder bone, which was broken, evidently when the animal fell. The well-preserved flesh and fat will be packed for shipment. I collected several dry and frozen bits of blood.

October 7.—To-day we packed up the right leg. I succeeded in removing a further portion of the stomach, which I will take with me, in a good state of preservation.

October 8.—The left side of the broken pelvis was removed. The flesh beneath this was found frozen hard as a stone and well preserved. The crossbone or sacrum was found intact.

October 9.—To-day we cut off the hind-legs, experiencing great difficulty with the thigh bones, so strongly were they joined with the tibia. The color of the hair of the right hind femur varies from rust-brown to black.

October 10.—After removing about 270 pounds of flesh, we started to raise the abdominal skin, which weighed about 470 pounds, when to our great joy we discovered the entire tail. This is short and consists evidently of 22 to 25 caudal vertebræ. The length, measured at the underside, is only 14½ inches, while the circumference at the base is 13 inches. It was covered with long, bristly hair, rust-brown in color. We could not decide to cut up the abdominal skin, and will attempt to take it with us intact.

October 11.—To-day we performed the last operations on the mammoth, after which all the parts were brought into the winter house, and securely packed away for transportation.

MAMMOTH FROM BERESOVKA IN THE ZOOLOGICAL MUSEUM IN ST. PETERSBURG, RECONSTRUCTED IN THE POSITION IN WHICH IT WAS FOUND.

Preservation of Plaster Casts.—Upon complete drying, small objects are laid for a short while in celluloid varnish of 4 per cent, while large articles are painted with it, from the top downward, using a soft brush. Articles set up outside and exposed to the weather are not protected by this treatment, while others can be readily washed off and cleaned with water. To cover 10 square meters of surface, 1 liter of celluloid varnish is required.—Chemiker Zeitung.

[Continued from SUPPLEMENT No. 1515, page 24276.]

BREEDING AND HEREDITY.*

WILLIAM BATESON, M.A., F.R.S.

SEGREGATION.

WHERE the proper precautions have been taken, the following phenomena have been proved to occur in a great range of cases, affecting many characters in some thirty plants and animals. The qualities or characters the transmission of which in heredity is examined are found to be distributed among the germ-cells, or gametes, as they are called, according to a definite system. This system is such that these characters are treated by the cell divisions (from which the gametes result) as existing in pairs, each member of a pair being alternative or *allelomorphic* to the other in the composition of the germ. Now, as every zygote—that is, any ordinary animal or plant—is formed by the union of two gametes, it may either be made by the union of two gametes bearing similar members of any pair, say two blacks or two whites, in which case we call it *homozygous* in respect of that pair, or the gametes from which it originates may be bearers of the dissimilar characters, say a black and a white, when we call the resulting zygote *heterozygous* in respect of that pair. If the zygote is homozygous, no matter what its parents or their pedigree may have been, it breeds true indefinitely unless some fresh variation occurs.

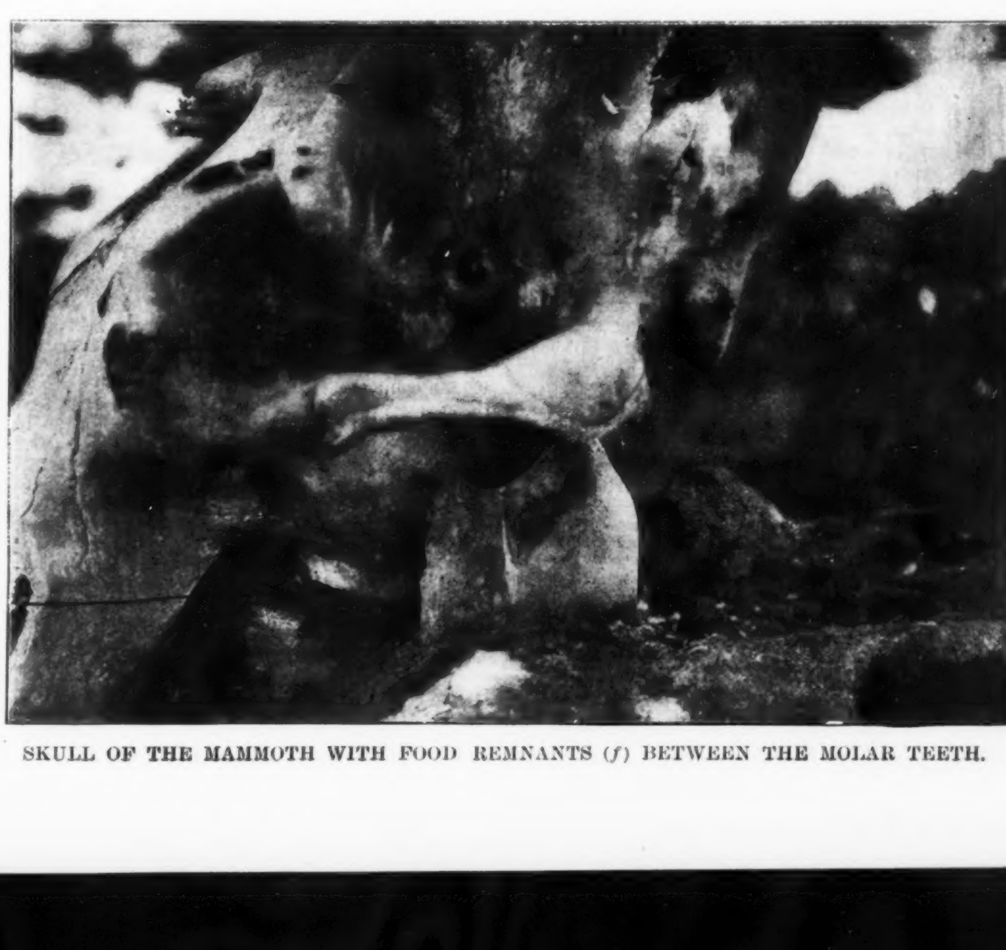
If, however, the zygote be heterozygous, or gametically cross-bred, its gametes in their formation separate the allelomorphs again, so that each gamete contains only one allelomorphic character of each pair. At least one cell division in the process of gametogenesis is therefore a differentiating or segregating division, out of which each gamete comes sensibly pure in respect of the allelomorph it carries, exactly as if it had not been formed by a heterozygous body at all. That, translated into modern language, is the essential discovery that Mendel made. It has now been repeated and verified for numerous characters of numerous species, and, in face of heroic efforts to shake the evidence or to explain it away, the discovery of gametic segregation is, and will remain, one of the lasting triumphs of the human mind.

In extending our acquaintance of these phenomena of segregation we encounter several principal types of complication.

Segregation Absent or Incomplete.—From our general knowledge of breeding we feel fairly well satisfied that true absence of segregation is the rule in certain cases. It is difficult, for instance, to imagine any other account of the facts respecting the American Mulattos, though even here sporadic occurrence of segregation seems to be authenticated. Very few instances of genuine absence of segregation have been critically studied. The only one I can cite from my own experience is that of *Pararge egeria* and *egeriades*, "climatic" races of a butterfly. When crossed together, they give the common intermediate type of northwestern France, which, though artificially formed, breeds in great measure true. This crossed back with either type has given, as a rule, simple blends between intermediate and type. My evidence is not, however, complete enough to warrant a positive statement as to the total absence of segregation, for in the few families raised from pairs of artificial intermediates some dubious indications of segregation have been seen.

The rarity of true failure of segregation when pure

* Read before the section of zoology of the British Association for the Advancement of Science.



SKULL OF THE MAMMOTH WITH FOOD REMNANTS (*f*) BETWEEN THE MOLAR TEETH.

strains are crossed may be judged by the fact that since the revival of interest in such work hardly any thoroughly satisfactory cases have been witnessed. The largest body of evidence on this subject is that provided by De Vries. These cases, however, present so many complexities that it is impossible to deal with them now. While so little is definitely known regarding non-segregating characters, it appears to me premature to attempt any generalization as to what does or does not segregate.

Most of the cases of failure of segregation formerly alleged are evidently spurious, depending on the appearance of homozygotes in the second generation (F_2).

One very important group of cases exists, in which the appearance of a partial failure of segregation after the second generation (F_2) is really due to another phenomenon. The visible character of a zygote may, for instance, depend on the coexistence in it of two characters belonging to distinct allelomorphic pairs, each capable of being independently segregated from its fellow, and forming independent combinations. For the demonstration of this important fact we are especially indebted to Cuénot.* We have indications of the existence of such a phenomenon in a considerable range of instances (mice, rabbits [Hurst], probably stocks and sweet peas).

Nevertheless, there are other cases, not always easy to distinguish from these, where some of the gametes of F_2 certainly carry on heterozygous characters unsegregated. As an example, which seems to me indisputable, I may mention the so-called "walnut" comb, normal to Malay fowls. This can be made artificially by crossing rose-comb with pea-comb, and the cross-bred then forms gametes, of which one in four bears the compound unsegregated.† We may speak of this as a true *synthesis*.

In another type of cases segregation occurs, but is not sharp. The gametes may then represent a full series ranging from the one pure form to the other. Such cases occur in regard to some colors of *Primula sinensis*, and the leg-feathering of fowls (Hurst). In the second generation a nearly complete series of intermediate zygotes may result, though the two pure extremes (if the case be one of blending characters) may still be found to be pure.

Resolution and Disintegration.—Besides these cases, the features of which we now in great measure comprehend, we encounter frequently a more complex segregation, imperfectly understood, by which gametes of new types, sometimes very numerous, are produced by the crossbred. Each of these new types has its own peculiarities. We shall, I think, be compelled to regard these phenomena as produced either by a resolution of compound characters introduced by one or both parents, or by some process of disintegration, effected by a breaking up of the integral characters followed by recombinations. It seems impossible to imagine simple recombinations of pre-existing characters as adequate to produce many of these phenomena. Such a view would involve the supposition that the number of characters pre-existing as units was practically infinite—a difficulty that as yet we are not obliged to face. However that may be, we have the fact that resolutions and disintegrations of this kind—or recombinations, if that conception be preferred—are among the common phenomena following crossing, and are the sources of most of the breeder's novelties. As bearing on the theoretical question to which I have alluded, we may notice that it is among examples of this complex breaking up that a great proportion of the cases of partial sterility have been seen.

No quite satisfactory proof as to the actual moment of segregation yet exists, nor have we any evidence that all characters are segregated at the same cell division. Correns has shown that in maize the segregation of the starch character from the sugar character must happen before the division forming the two generative nuclei, for both bear the same character. The reduction division has naturally been suggested as the critical moment. The most serious difficulty in accepting this view, as it seems to me, is the fact that somatic divisions appear sometimes to segregate allelomorphs, as in the case of Datura fruits, and some color cases.

In concluding this brief notice of the complexities of segregation I may direct attention to the fact that we are here engaged in no idle speculation. For it is now possible by experimental means to distinguish almost always with which phenomenon we are dealing, and each kind of complication may be separately dealt with by a determination of the properties of the extracted forms. Illustrations of a practical kind will be placed before you at a subsequent meeting.

The consequence of segregation is that in cases where it occurs we are rid of the interminable difficulties which beset all previous attempts to unravel heredity. On the older view, the individuals of any group were supposed to belong to an indefinite number of classes, according to the various numerical proportions in which various types had entered into their pedigree. We now recognize that when segregation is allelomorphic, as it constantly is, the individuals are of three classes only in respect of each allelomorphic pair—two homozygous and one heterozygous. In all such cases, therefore, fixity of type, instead of increasing gradually generation by generation, comes suddenly, and is a phenomenon of individuals. Only by the separate analysis of individuals can this fact be proved. The supposition that progress toward fixity of type was gradual arose from the study of masses of individuals, and the gradual purification witnessed was due in the main to the gradual elimination of impure individuals, whose individual properties were wrongly regarded as distributed throughout the mass.

We have at last the means of demonstrating the presence of integral characters. In affirming the integrity of segregable characters we do not declare that the size of the integer is fixed eternally, as we suppose the size of a chemical unit to be. The integrity of our characters depends on the fact that they can be habitually treated as units by gametogenesis. But even where such unity is manifested in its most definite form, we may, by sufficient searching, generally find a case where the integrity of the character has evidently been impaired in gametogenesis, and where one such individual is found the disintegration can generally be propagated. That the size of the unit may be changed by unknown causes, though a fact of the highest significance in the attempt to determine the physical nature of heredity, does not in the least diminish the value of the recognition of such units, or lessen their part in governing the course of Evolution.

The existence of unit characters had, indeed, long been scarcely doubtful to those practically familiar with the facts of variation (*cp.* De Vries, "Intracellulare Pangenesis," 1889), but it is to the genius of Mendel that we owe the proof. We knew that characters could behave as units, but we did not know that this unity was a phenomenon of gametogenesis. He has revealed to us the underworld of gametes. Henceforth, whenever we see a preparation of germ-cells we shall remember that, though all may look alike, they may in reality be of many and definite kinds, differentiated from each other according to regular systems.

NUMERICAL RELATIONS OF GAMETES AND THEIR SIGNIFICANCE.

In addition to the fact of segregation, Mendel's experiments proved another fact nearly as significant; namely, that when characters are allelomorphic, the gametes bearing each member of a pair generally are formed in equal numbers by the heterozygote, if an average of cases be taken. This fact can only be regarded as a consequence of some numerical symmetry in the cell divisions of gametogenesis. We already know cases where individual families show such departure from normal expectation that either the numbers produced must have been unequal, or subsequent disturbance must have occurred. But so far no case is known for certain where the average of families does not point to equality.

The fact that equality is so usual has a direct bearing on conceptions of the physical nature of heredity. I have compared our segregation with chemical separation, but the phenomenon of numerically symmetrical disjunction as a feature of so many and such different characters seems scarcely favorable to any close analogy with chemical processes. If each special character owed its appearance to the handing on of some complex molecule as a part of one chemical system, we should expect, among such a diversity of characters and forms of life, to encounter some phenomenon of valency, manifested as numerical inequality between members of allelomorphic pairs. So far, equivalence is certainly the rule, and where the characters are simply paired and no resolution has taken place, this rule appears to be universal as regards averages. On the other hand, there are features in the distribution of characters after resolution, when the second generation (F_2) is polymorphic in a high degree, which are not readily accounted for on any hypothesis of simple equivalence; but none of these cases are as yet satisfactorily investigated.

It is doubtful whether segregation is rightly represented as the separation of two characters, and whether we may not more simply imagine that the distinction between the allelomorphic gametes is one of presence or absence of some distinguishing element. De Vries has devoted much attention to this question in its bearings on his theory of Pangenesis, holding that cases of both kinds occur, and attempting to distinguish them. Indications may certainly be enumerated pointing in either direction, but for the present I incline to defer a definite opinion.

If we may profitably seek in the physical world for some parallel to our gametic segregations, we shall, I think, find it more close in mechanical separations, such as those which may be effected between fluids which do not freely mix, than in any strictly chemical phenomenon. In this way we might roughly imitate both the ordinary segregation, which is sensibly perfect, and the curious impurity occasionally perceptible even in the most pronounced discontinuities, such as those which divide male from female, petal from sepal, albino from colored, horn from hair, and so on.

(To be continued.)

* When $abc \ldots \times \alpha\beta\gamma \ldots$ gives in F_1 or F_2 a character (not seen in the original parents), which from F_2 or later may breed true; not because $a\alpha$, $b\beta$, $c\gamma$ do not severally segregate, but through simultaneous homozygosis of, say, aa and $\beta\beta$, giving a zygote $aa\beta\beta c\gamma \ldots$ which will breed true to the character $a\beta$.

† Owing to this behavior, and to the simultaneous production of single-comb (? by resolution), there are, even in pure Malays, five types of individuals, all with "walnut" combs—as yet indistinguishable—formed by gametic unions $r \times p$, $rp \times rp$, $rp \times r$, $rp \times p$, $rp \times s$. Of these kinds three can at once be distinguished by crossing with single; but whether $r \times p$ can be distinguished from $rp \times s$ we do not yet know. [r, rose; p, pea; s, single; rp, walnut.] In this example four allelomorphs are simultaneously segregated, one being compound. Neglecting sexual differentiation, there are therefore ten gametically distinct types theoretically possible; but of these, only four are distinguishable by inspection.

TUNGSTEN: ITS USE AND VALUE.

ENERGETIC prospecting due to an increased demand and high prices, has proved the existence of deposits of tungsten-bearing minerals in the United States, Canada, Australia, New Zealand, Great Britain, Saxony, Bohemia, and Spain, says the American Manufacturer. But not all of these deposits are productive of good mineral, a fact that partly explains the maintenance of remunerative prices for tungsten. The chief sources of the metal are wolframite, hubnerite and scheelite, in association with which are often found cassiterite, auriferous pyrite and other substances from which the tungsten must be freed to be of value industrially. By hand sorting, crushing and jigging, and magnetic concentration it is possible to eliminate the impurities and enrich the tenor of tungsten in the ore. Not infrequently the ore as mined will contain only 5 per cent to 8 per cent of metallic tungsten, and to be marketable it must be brought to an average of 50 per cent to 70 per cent tungstic acid, the unit basis of selling price. It is essential that ore be free, or nearly so, from phosphorus and sulphur, but the presence of carbon and silica will not be considered injurious. At present an ore averaging 60 per cent WO_3, and containing not more than 0.25 per cent phosphorus, and 0.01 per cent sulphur, can be sold in New York at \$7 per unit of tungstic acid, equivalent to \$420 per long ton. For higher grade ore, up to \$7.50 per unit is quoted, because just now the demand exceeds the supply. It is customary to contract for ore on a basis of 90 per cent cash on delivery f. o. b. New York, the balance of 10 per cent being retained for a month to allow time for a comparison of assays and adjustment of possible differences between buyer and seller.

Tungsten as a metal of 95 per cent to 99 per cent purity, or alloyed with iron in the proportion of 37 per cent up, finds its greatest consumption in the steel industry, notably in Europe, where the demand is about eight times as large as in America. The world's consumption amounts to something like 700 to 800 tons per annum, which is a relatively large quantity, when it is considered that usually only 5 per cent to 8 per cent tungsten is needed in the mixture of so-called self-hardening steel. A typical ore, used by German steel works, analyzes from 60 per cent to 76 per cent WO_3, 8 per cent to 10 per cent FeO, 9 per cent to 12 per cent MnO, and 0.4 per cent to 1 per cent CaO. Exports from America have been made to Europe, and the ore has been so satisfactory that further inquiries are being received. The annual production in the United States is between 3,000 and 5,000 short tons of crude ore, which will yield from 200 to 360 tons of 50 per cent to 65 per cent concentrate.

For a long time only a comparatively small part of the domestic ore output was consumed locally, but with continued expansion in the manufacture of metallic tungsten, a marked change has taken place. In 1902 the United States made 82,000 pounds tungsten metal, 14,000 pounds ferro-tungsten, and 3,500 tungstic acid and tungstate of soda, all of which products will probably show further increase. Tungsten metal made in the electric furnace, and analyzing 99 per cent, sells at \$1.25 per pound in New York; ferro-tungsten, 37 per cent, at 45 cents per pound. Metallic tungsten has a specific gravity of 18.7, is practically free from carbon, can be welded and filed like iron, and when used in tool steel the alloy preserves its hardness, even when heated to temperatures that would rapidly draw the temper from ordinary high carbon steel. In the manufacture of permanent magnets, used in the construction of electric meters, the steel employed contains approximately 5 per cent to 6 per cent tungsten. An alloy of 5 per cent tungsten and 6 per cent steel will make a shell for lead bullets that has much higher penetrating power than ordinary lead. Tungsten steel may also be used for armor plate. Metallic aluminium can be hardened advantageously with tungsten, its resistance to oxidation making it much superior to copper. A small percentage of tungsten will also greatly increase the carrying power of spring steel. Tungsten steel is employed in the sounding plates of pianos.

Vegetable tissues are rendered incombustible by the use of tungsten compounds. Usually the material to be treated is coated with tungstic acid and glue, or with tungstate of soda and muriatic acid in a thick solution of glue.

In figuring percentages of tungsten ore it must be noted that the atomic weight is very high, 184, so that the difference between the tenor, quoted as metal and as oxide, is not as great as in the case of iron.—Mining and Scientific Press.

COMPOSITION OF GASES FROM MINERAL SPRINGS, HELIUM, ETC., AND RADIO-ACTIVITY.

IN connection with M. Curie's recent researches upon the radio-active properties of gases from mineral springs, the following experiments made by M. Charles Moureu, of Paris, are not without interest. M. Curie showed the presence of radium emanation in the gases which escape from mineral springs and among other results this gives a plausible explanation of some of the obscure points relating to the action of mineral waters upon the system. In any case, it shows how various may be the factors which enter into such action upon the animal economy. As a natural consequence of their physical examination comes a chemical examination of the radio-active gases of the springs, in order to find out their composition. The chemical observation will also be of great interest from the following fact. According to the late researches of Ramsay and Soddy, Dewar, Curie, Deslandres, and others, the radium emanation is a veritable gas and is destroyed, giving helium, and this fact is correlated to the disappearance of the radio-activity of the gase-

ous mixture. It is desired that this result, in view of its importance, should be confirmed by new experiments. We already remark that it is in concord with the fact that helium exists in all the known radioactive mixtures. If we generalize from this idea, helium should be to some extent the companion of radium in nature and we should expect to find it wherever we see radium and its emanation. Besides, it is possible that the earth contains another radioactive matter which undergoes the same changes as radium with a final production of helium or other gases of the same order (argon, neon, crypton, etc.). In view of these facts, the different mineral waters, on account of their great number and the variety of their origins, offer a very good field for such researches.

During recent years, different springs were made the object of an exhaustive chemical examination. We may mention the researches of Bouchard on the Cauterets water and those of Desgrez on the Bagnoles springs, Nasini and Anderlini on the *suffioni* of Laderello and the Albano hot springs, Moisson on the Luchon springs, Dewar on the King's Well, and the author's researches on the Maizières water and five springs in the Pyrenees. The Cauterets, Bagnoles, and Eaux-Bonnes are among those in which M. Curie found radio-active matter, and these three also contain helium. The author has just made a series of researches on twelve other radio-active springs. The method is based on the absorption of the nitrogen and oxygen by a lime-magnesia mixture. The spectroscopic examination of the non-absorbable gaseous residue (argon, helium, etc.) was in some cases completed by spectrophotographic observation in M. Deslandres' laboratory at the Meudon Observatory. Besides argon, which seems to exist in most of the gaseous mixtures, the twelve springs now examined all showed the characteristic specter of helium. Without assuming the relative proportion of argon and helium, which we cannot state exactly at present, we remark that in nearly all the springs the main ray of helium, $\lambda = 587.6$ was at least as bright as the most intense rays of argon. In the Chomel spring (Vichy) we find it on the contrary much weaker, although it is well visible. M. Moureu gives a table of the composition of the radio-active gases from the twelve springs as to carbonic acid, oxygen, nitrogen, and the last portion containing argon, helium, and other rare elements which are to be separated later. The latter are all figured together here. Without giving the whole of the table here, we may mention that the proportion of the latter gases varies from 0.50 in the Chomel (Vichy) spring to 2.06 in the Luxiel spring. The degree of radio-activity, however, does not keep parallel with the proportion of argon and helium. The springs in the order of their radio-activity are those of Badgastien (Austria), Plombieres, Vosges (five springs), Luxiel (two springs), Vichy, Neris, Salins, Moutiers (Savoy), Eaux-Bonnes. The more active springs are at the top of the list. All except the first are in France. There is a wide difference in the activity, thus the Plombières spring is fifty times as active as the last one in the list.

GEORGE WASHINGTON AS AN ENGINEER.

WHILE yet a lad, Washington left a comfortable home to spend a long period in the wild regions of the head-waters of the Potomac, Youghiogheny, and Monongahela. When, in the early part of 1748, just after he passed into his sixteenth year, he made the expedition into the interior of northern Virginia, to survey the lands of Lord Fairfax, he ventured upon as great a task as would now characterize a journey to the poles or to the interior of Alaska or Africa. For it must be remembered that the means of dealing with natural difficulties were far cruder than at present, and that while the weapons of offense and defense available to civilized men were superior to those of savages, yet they were far inferior to those now in use.

Washington's proficiency in the procedures involved in engineering enterprises was manifested in very early life. His first remunerative labor of which we have definite record was in surveying portions of the lands of Lord Fairfax, located in what was then known as the "Northern Neck" of Virginia, now included, in part, in West Virginia. During the spring of 1748, when Washington had just turned sixteen years of age, a considerable emigration of settlers was taking place into the region of the Shenandoah, and a need for land surveying arose. The great grants of lands by European monarchs to favorites or adventurers (the latter term not then being a derogatory one) were often made vaguely, by assigning some line of longitude or latitude, or based on incomplete and erroneous maps. The office of surveyor was in good repute; persons of good social position could undertake it without derogation. That Lord Fairfax should have chosen for the important task of such surveys a youth not yet seventeen, speaks for the ability and trustworthiness that must have been recognized in young George, and the sequel amply demonstrated that Lord Fairfax made no mistake.

The notes of the surveys made for Lord Fairfax are in considerable part extant, and have been reprinted with great care by Dr. Toner. They begin with an entry "A Journal of my Journey over the Mountains began Fryday, the 11 of March 174-78."

"Fryday, March 11th, 1747-8. Began my Journey in Company with George Fairfax, Esq., we traveled this day 40 miles to Mr. Georg Neavels in Prince William County."

This start was made from the estate of Hon. William Fairfax, which, in a letter written many years later, Washington described as "within full view of Mount Vernon" and separated therefrom only by water. A few lines of the diary may be quoted exactly as written:

"Tuesday 15th We set out early with Intent to Run round ye sd Land but being taken in a rain & it Increasing very fast obliged us to return, it clearing about one oClock & our time being too Precious to Loose we a second time ventured out & Worked hard till Night & then return'd to Penningtons we got our Suppers & was Lighted into a Room & I not being so good a Woodsman as ye rest of my Company striped myself very orderly and went into ye Bed as they called it when to my Surprise I found it to be nothing but a Little Straw—Matted together without Sheets or anything else but only one thread Bear blanket with double its Weight of Vermin such as Lice Fleas &c I was glad to get up (as soon as ye Light was carried from us) I put on my Cloths & Lays as my Companions. Had we not been very tired am sure we should not have slep'd much that night I made a promise not to Sleep so from that time forward chusing rather to sleep in ye open Air before a fire as will appear hereafter."

This journal ends, as far as regards memoranda of the journey, on Wednesday, April 13, 1748 (O. S.), the entry being:

"Mr. Fairfax got safe home and I myself safe to my Brothers which concludes my Journal."

Many notes of surveys are entered, however, of later date up to Nov. 3, 1750 (O. S.). One of these will serve as an illustration of the style:

"April 2d 1750 Then Survey'd for Even Pugh a certain Tract of Waste and ungranted Land Situate in Frederick County on the Trout Run a branch of Cacapehon & bounded as followeth begg at a white Oak & two Poplars standg on the Run & Run thence S 85 Et Three hund and twenty Poles to two red Oaks two Gums & a Maple thence No 40 deg W Three hund & twenty poles to a white Oak from thence to the Begg S 27 Wt 244 Po Conh 226."

By the death of his brother, in 1752, Washington became the owner of Mount Vernon. While he did not do much detail survey work after this, yet he was very active in exploration, and in all his journeys he kept records, and observed facts that were to be applied by him in the furthering of great engineering enterprises.

In the autumn of 1784 he made a tour to the region included between the headwaters of the Potomac and Ohio, to renew his knowledge, to observe the progress of settlements, and to be enabled to formulate more precisely plans for the construction of a public highway across the mountains. Shortly after his return from this expedition, October 10, 1784, he wrote a long letter to Benjamin Harrison, Governor of Virginia, in which he set forth in much detail the views he held and the difficulties to be overcome.

About this time Washington made a map showing the water-courses of the Potomac and Ohio and the relation of them to the main divide between these river systems. The plan was to establish a portage across the divide. More than a quarter of a century afterward the United States engineers, after their surveys, laid down a portage line only about a mile below that suggested by Washington. Another and longer line of portage is indicated from Cumberland into a region which is now part of Fayette County, Pennsylvania. He had studied this latter region in his campaign of 1754, that ended in the disaster at Fort Necessity.

As a result of his efforts the Potomac Company was organized, the forerunner of the Chesapeake & Ohio Canal Company, companies whose history is too well known to be reviewed here.—The Engineering Record.

A PORTO RICO FOREST RESERVE.

THAT one of our national forest reserves is in Porto Rico is a fact of which very few people in the United States are aware. Yet both in the extraordinary variety of botanical species which its forests contain and in the picturesqueness and novelty of its scenery this reserve stands second to none of those in our Western States, while it has the unique distinction of being the only tropical forest which this country owns on this side of the globe.

The Luquillo forest reserve was created by Presidential proclamation in January, 1903. It embraces some 65,950 acres of land in the eastern and most mountainous part of the island. Compared with most of the Western reserves, this is small. But the whole island of Porto Rico is only about three-quarters the size of Connecticut and consequently offers no room for a large reserve.

The Luquillo reserve was set aside from certain public lands in Porto Rico which were formerly the property of the Spanish government. It is joined by private holdings and also to some extent by lands the title to which is now vested in the insular government, which is possessed of all lands not reserved by the federal government before June 30, 1903. The whole region within which the reserve lies has never been surveyed or accurately mapped, and the boundaries between the private and public holdings are very vague and undefined. In practice the agriculturists to whom the private lands belong have pushed their clearings as far up the mountain sides as it was profitable for them to go, and have helped themselves more or less to whatever timber they needed from the accessible forest beyond. These depredations have not been, on the whole, very serious, owing to the tropical character of the forest and the difficulties of transportation, but the exact definition of the line between the reserve and the adjoining private owners is a pressing need.

To secure information concerning present conditions and a basis for recommendations to the insular government for a future policy, Dr. John C. Gifford was sent by the Bureau of Forestry, in the summer of 1903, to make an examination of the reserve. He found that only about 20,000 acres are forest lands unclaimed by private owners, and half of this is in mountain peaks and palm lands, so that there are only 10,000 acres of productive timber. Nevertheless, the whole reserve stands in an important relation to the economic welfare of the people who live near it, and the benefits of its establishment will be increasingly manifest as time goes on.

Even to the natives the region embraced in the reserve is little known. It is a small wilderness of serrated mountains, tropical forest, and rushing torrential streams, concerning which all sorts of fantastic fables find currency. It covers a large part of the Sierra de Luquillo, a mountain mass separated from the mountains of the rest of the island by the valley of the Loiza, the largest river in Porto Rico. One of its peaks, El Yunque, is the highest mountain of the island, with an altitude of some 3,300 feet. Upon the eastern slopes of these mountains, which face the sea, the westward-blowing trade winds pour an enormous precipitation, the heaviest in the island. In 1902 the total was almost 142 inches. This rainfall is well distributed throughout the year. In the highest mountains it is rare for twelve hours to pass without some rain. As a rule heavy, drenching showers alternate with bright sunshine. The result is violent fluctuations in the streams, which often leap into impassable floods and subside again within an hour or two.

It is as an agency for the control of these flood waters that the Luquillo Reserve is likely to render the most valuable service. To some extent the forest will even supply water for agriculture, for immediately to the south and west of the mountains the climatic conditions become very different from those on the always profusely watered eastern slopes. The country is drier, evaporation more active, and the vegetation correspondingly changes its character. So while parts of the island are drenched with water most of the time, other parts, half a day's ride distant, are dependent upon irrigation. But generally it is against too much water rather than the want of it that the protection of the forest is needed. Even with the mountains forest-covered, floods have caused great destruction. Massive stone bridges have been carried away, roads damaged, farms and pastures ruined, and lives lost. Stripped of their forests, the mountains would soon be washed bare of soil and the lowlands swept by floods after every heavy shower.

What the value of the reserve will be as a source of timber supply is more or less problematical. Mahogany, if ever present in the forest, as seems probable, has been entirely exterminated, and the cigar-box cedar is also practically gone. Valuable woods remain, but the essentially tropical character of the forest, in which a great number of species contend with one another for possession, makes the problem of management a very difficult one. "Weed trees" abound and there is no uniformity of forest growth. Individuals of the same species occur scattered sparsely and irregularly through the dense forest, and it is an extraordinary fact that within so narrow a range as the island affords certain kinds which in some places grow to be large and beautiful timber trees elsewhere exist as shrubs.

The best of the forest in the reserve is that found in the fertile gorges, ravines, and coves from 500 to 2,000 feet above sea level, where the trees are protected from the constant winds. There are four leading timber trees—the tabapuco, with a wood very like our sycamore, the laurel sabino, which would grade in the market with yellow poplar, the ausubo, comparable with black walnut, and the guaraguao, similar to red cedar. All these trees reach a large size, ranging from 2 to 5 feet in diameter. The tabanuco has, in addition, the very valuable characteristic that it tends to form pure or nearly pure stands. It produces a kind of gum which may prove to be an article of commercial importance.

Many climbing vines add to the density of the vegetation. There is also a species of grass which grows 5 feet high and cuts like a razor at the lightest touch. But the most abundant growth is that of the mountain palms. They are very beautiful, but of little or no value, and to get rid of them will be at once a necessary and most difficult matter if permanent production of salable timber is to be secured. They grow 40 feet high, and already cover fully half of the best part of the reserve. Yielding as they do an immense amount of seed, and growing very thickly, nothing else in the forest can compete with them for possession on anything like equal terms, so that unless they can be artificially held in check they will certainly gain most of the ground left vacant by the removal of trees cut for timber. They are true weed trees of the most aggressive kind.

Above two thousand feet altitude the trees are stunted, gnarled, and slow-growing, of many different species, with moss-covered limbs and roots often bare. They are of no commercial value but are of great importance as a protective forest cover.

Dr. Gifford believes that the Luquillo reserve should be cared for and developed along two distinct lines. From an economic point of view it should be managed to secure the best returns from the sale of

timber and other forest products, consistent with the maximum protection of the water-sheds. It should also be made accessible to the public for its scenic attractions. Roads should be opened and fish and game introduced. At the same time from a scientific standpoint the extraordinary interest of its undescribed flora opens a splendid opportunity for studies of tropical forest botany. This report is now in press. When issued it can be obtained upon application to the Forester, United States Department of Agriculture, Washington, D. C.

[Continued from SUPPLEMENT No. 1515, page 24281.]

ON THE MODERN REFLECTING TELESCOPE, AND THE MAKING AND TESTING OF OPTICAL MIRRORS.*

By G. W. RITCHEY.

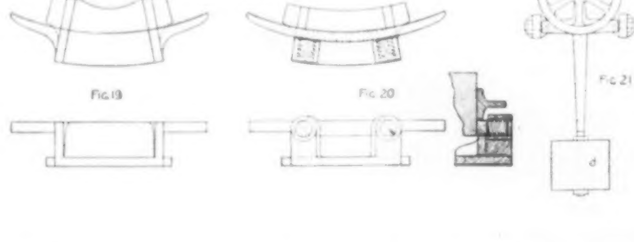
XV. SILVERING.

It is not my purpose to discuss the various processes of silvering. Several methods have been admirably described by Draper, by Brashear, and by Common (see p. 159 of his paper "On the Construction of a Five-Foot Reflecting Telescope"). I have used almost exclusively the formula published by Brashear in 1884, in which sugar is the reducing agent. After experience with this process, and when the grades of chemicals specified below are used, silver films are invariably obtained which take a perfectly black polish, and which are so thick as to be nearly opaque even to the sun's disk. Small mirrors are usually silvered face down; films which are satisfactory in all respects are obtained when this is done.

In the case of large mirrors it is more economical of silver, as well as safer and more convenient in manipulation, to silver face up. Two difficulties occur, however, when this is done; first, minute transparent spots are liable to occur in the film; these are so small, however, that they can be seen only when looking through the film at a bright object; second, the refuse silvering solutions must be poured off the mirror, after the silver has been deposited, at exactly the right stage of the reaction; if poured off too soon the film will be thin; if too late, the muddy-brown precipitate which settles upon the film will slightly tarnish the latter in such a manner that it will not take a perfect polish; it is only by experience that the optician is able to determine the right instant for pouring off the refuse solutions. Mr. Common encountered similar difficulties in silvering face up, and resorted to the use of solutions without caustic potash, and also to the use of Draper's method of reducing with Rochelle salt; these methods, while subject to their own special difficulties, do not give the objectionable precipitate. The writer has adhered to the use of a slight modification of Brashear's formula already mentioned, in part because no opportunity has occurred for comparing thoroughly the merits of the various formulæ, and in part because the films obtained by this method give entire satisfaction in use.

The Reducing Solution.—This consists of distilled water, 200 parts; loaf-sugar or pure rock-candy, 20 parts; alcohol (pure) 20 parts; nitric acid (c. p.) 1 part. The proportions given are by weight. This solution is greatly improved by keeping, a solution which has been made for several months working more surely than one newly made. A gallon of this solution is usually made at one time.

The operation of silvering a 2-foot mirror face up will now be described. It will be assumed for the present that the back of the mirror is unsilvered. A silvering table is used, which is a strong structure of oak wood having a tilting frame carried on two trunnions, so that the mirror can be quickly turned from a horizontal to a vertical position, for the purpose of pouring off the cleaning and silvering solutions; a strong narrow edge-band of flexible steel prevents the mirror from sliding off; the tilting frame is heavily weighted below so that it cannot turn down accidentally. Thus all handling of the mirror while silvering is avoided.



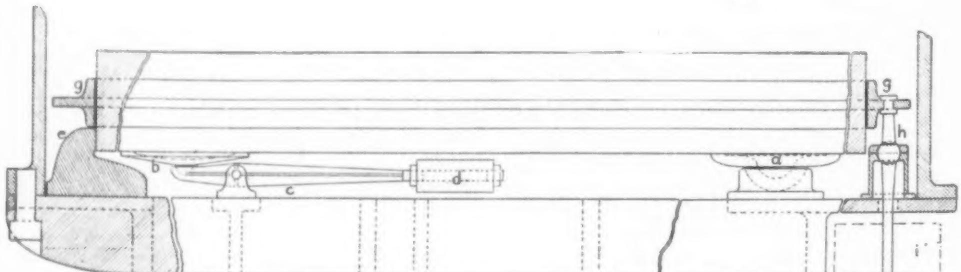


FIG 17

SUPPORT SYSTEM FOR LARGE MIRROR.

The old silver film, if one exists, is removed with strong nitric acid on a bunch of absorbent cotton tied to a glass rod. The face and edge of the mirror are then quickly washed with distilled water. A band of strong brown drawing paper, which has been dipped in melted paraffin, is drawn around the edge of the glass and tightly bound to it by means of a thin band of copper with tightening screws; the paper should project about three inches above the glass; the joints should all be made water-tight by means of more paraffin and a warm iron. A dish about three inches deep is thus formed, with the mirror as its bottom.

A 10 per cent solution of pure caustic potash in distilled water is now used for thoroughly washing the face of the glass and the inside of the paraffin band; this is done with a large bunch of absorbent cotton tied to a glass rod. This solution is then poured out and the glass is similarly washed several times with fresh supplies of distilled water, to get rid of all traces of potash. Enough distilled water is now poured on the glass to entirely cover it while the silvering solutions are being mixed.

All of the vessels, graduates, etc., used for mixing the silvering solutions, must be thoroughly washed, first with nitric acid, then with caustic potash, and rinsed with distilled water, just as the mirror is cleaned.

For silvering the face of a 2-foot mirror, 2 ounces of silver nitrate (Powers & Weightman) are dissolved in 20 ounces of distilled water. One and one-third ounces of caustic potash, pure by alcohol (Merck), are dissolved in 20 ounces of water in a separate vessel, and the solution is cooled. Strong aqua ammonia (pure) is added, drop by drop, to the nitrate solution, while the liquid is thoroughly stirred; the mixture turns light brown, then dark brown; the ammonia is slowly added until the liquid becomes clear. The caustic potash solution is now added slowly, with thorough stirring; the mixture now becomes very dark brown or black. Ammonia is again added, with thorough stirring, until the liquid again just clears. A solution of one-fourth ounce silver nitrate in 16 ounces of distilled water having been prepared, this is added to the mixture, a few drops at a time, with thorough stirring, until the entire solution has a decided straw color, while remaining transparent. This straw color is the test for the condition of instability which is absolutely necessary in order that the metallic silver shall be thrown out of combination when the reducing solution is added later. The solution is now thoroughly filtered through absorbent cotton.

A quantity of reducing solution is taken containing an amount of sugar equal in weight to one-half that of the entire amount of silver nitrate used; this is also filtered. The silver solution and reducing solution are now both diluted with distilled water, preparatory to mixing; the quantity of the diluted solutions, together, should be sufficient to cover the glass about one inch deep.

An assistant pours off the water which has stood on the glass, while the optician quickly mixes the dilute silver and reducing solutions in a large pitcher or granite-ware bucket. The glass being horizontal, the mixed solution is immediately poured on, and the mirror is rocked slightly by means of the tilting frame. The liquid quickly changes to a transparent light brown color, then dark brown, then black, after which the silver immediately begins to deposit. The solution gradually changes to a muddy brown color, and in three or four minutes after the solutions are poured on the glass, begins to clear, the light muddy brown precipitate settling upon the film. With the proportions given, the silver film should be sufficiently thick in about five minutes after the solutions are poured on the glass provided that the room, glass, and solutions are all at a temperature of sixty-eight degrees or seventy degrees Fahrenheit. When first formed the brown precipitate is so light that it moves about with the rocking of the glass; but it very soon deposits in large areas on the film. As soon as this begins to occur, the solution must be very quickly poured off the glass, an abundance of distilled water poured on, and a large bunch of absorbent cotton, held in the fingers, instantly used to displace all streaks of the precipitate which adhere to the film. The film is now washed again and again with fresh distilled water and a soft bunch of cotton; then an abundance of water is poured on and the film allowed to soak for an hour. When this is poured off, the paper band is carefully removed, with the glass horizontal so that no liquid from the edge can run upon the silver film; this must be done quickly, before the latter has time to dry. A small amount of alcohol is now flowed on the film; this is repeated several times to get rid of all water; the glass is then turned on edge, and is quickly dried with a fan.

After standing for an hour or two in a dry room, the film is to be burnished. A soft pad as large as the hand is made of the softest chamois skin; this is used on the film without rouge, with light circular strokes, to condense the silver. After two hours of this work a little of the finest washed dry jeweler's rouge is rubbed into the chamois-skin with a piece of clean absorbent cotton; from thirty to sixty minutes use of the pad with the same stroke as before should now bring the film to a perfect polish, without scratches.

If the back of the mirror is already silvered, the face can be silvered by the method just described, without injuring the film on the back; the mirror now rests upon three curved and beveled blocks of soft wood which touch only the rounded corner or edge of the back of the glass; extra precautions are now taken to prevent any of the solution from touching the back. I regard this method as much better in the case of large mirrors than to attempt to silver both back and face at the same time in a deep tray; in the latter method the difficulties of handling and properly cleaning the mirror are almost insurmountable.

The back of the mirror does not usually need silvering oftener than once in three or four years. The face is usually silvered two or three times a year, to keep it in the finest condition for photography, in which any yellowing of the film is very objectionable.

XVI. A SUPPORT-SYSTEM FOR LARGE MIRRORS.

The proper support of mirrors in their cells when in use in the telescope is a matter of vital importance. Small mirrors can be made very thick and can be supported at their edges as a lens is supported; the cell must be so designed that no sensible change of position of the mirror in its cell can occur. The necessity of supporting large mirrors in such a manner as to prevent flexure from their own weight, in all positions which can occur in use, has long been recognized, and elaborate support-systems for this purpose have been devised and used by Rosse, Grubb, Common, and others. Comparatively little attention has been given, however, to two additional requirements which are no less important; first, the position of the

* Reprinted from vol. xxxiv, Smithsonian Contributions to Knowledge.

mirrors in their cells should be defined with the greatest attainable stability, in order to secure permanence of adjustment or collimation; second, the method of support should be such that the silvered back of the mirror is exposed to the air as freely as possible. It is assumed that a large mirror need never be turned farther than ninety degrees from the position in which it lies horizontal upon its back.

In the Astrophysical Journal for February, 1897, the writer described a method of supporting large mirrors which fulfills all of the requirements named in the preceding paragraph. I have employed this method in the designs for the support-system of the 5-foot mirror. These designs are described and illustrated here.

I. The Back-Support.

Let us consider the mirror to be divided into twelve imaginary segments of equal weight, as shown in Fig. 16. The back of the mirror rests, primarily, upon three strong bronze plates, each ten inches in diameter, represented by the double circles *a*, Fig. 16, and at *a*, Fig. 17, the center of each plate being exactly behind the center of weight of the corresponding segments; these are called the stationary plates. The upper surface of each plate is flat and is ground to fit the flat back of the glass; the lower surface is spherical, and is ground to fit the large spherical socket in which it rests. It will be noticed that these plates are near the edge of the mirror, in the outer ring of segments; the base of stable support is therefore large. It is evident that by properly designing these plates and their supports we can fix with very great stability the plane of the mirror which rests directly upon them; there is no building out from the three primary points of support by means of intermediate levers and triangles, as in the older systems.

The weight of the remaining nine segments of the mirror is just balanced by means of nine weighted levers, each of which is entirely independent of every other, which lie in a plane parallel to the back of the mirror. One of these levers is shown in elevation at *c*, Fig. 17, and in plan in Fig. 21. The positions of the nine levers are indicated by dotted crosses in Figs. 16 and 18. These levers are suspended between pivots screwed through lugs connected to the cell. The cone bearings, shown in Fig. 21, are finely fitted, and are ground to reduce friction. The long arms of the levers carry adjustable lead weights (*d*, Figs. 17 and 21) which are made in the form of plates, in order that they may occupy as little space as possible perpendicular to the plane of the mirror; the short arms of the levers are thus made to press against the backs of the corresponding segments through the medium of light plates of bronze represented by the single circles *b*, Fig. 16, and at *b*, Figs. 17 and 21.

The large mirror weighs very nearly 2,000 pounds, so that each segment weighs 166 2-3 pounds. With the cell in a horizontal position the lead weight on each arm is adjusted until it just balances a standard weight of 166 2-3 pounds placed upon the plate on the short arm. This adjustment being completed, the mirror is laid upon the support-system; three-quarters of its weight is carried by the nine levers, leaving one quarter to be divided equally between the three heavy plates *a*. Thus each of the twelve segments is entirely supported at the back, independently of all of the other segments. Now suppose that the edge-support, which will be described below, be introduced, and the entire system, with the glass, inclined in any direction and at any angle; all of the levers and weights retain the same position as before with reference to the glass, but they do not exert the same pressure on account of the inclination; so far as the back-support is concerned there will still be a perfect balance maintained in the case of each segment; this is true whatever point of the edge of the mirror becomes lowest—i.e., in whatever direction the levers lie with respect to the vertical plane through the axis of figure of the mirror.

It should be noticed that in the case of each of the twelve 10-inch supporting plates only a ring one inch wide around the edge is in contact with the glass; the part of each plate inside of this ring consists of deep, narrow arms, which do not touch the glass, and which allow free access of air to the latter.

For very large or thin mirrors a larger number of plates and levers can, of course, be used. An incidental advantage which occurs when this is done is that the base of stable support afforded by the three stationary plates is still larger, compared with the size of the mirror, than when twelve plates are used.

II. The Edge-Support.

The relation between the back-support and edge-support is so intimate that any inefficiency in the latter must injuriously affect the operation of the former, however perfect that may be in itself. In an equatorial reflecting telescope, different parts of the edge of the mirror become successively lowest, as the position of the telescope changes. With the flexible band and cushioned edge-support so much used in the past, the heavy mirror necessarily changes its position, laterally, with respect to its cell, in taking its position down against the edge-support; thus not only is permanence of position lost, but this tendency to lateral shift must impair the freedom of operation of the back-support system.

In the present plan four metal arcs are used which rigorously define the position of the mirror laterally. Two of these arcs (*e*, Figs. 16 and 17, and Fig. 19), adjacent to each other, are bolted down to the cell, and their inner edges are scraped to fit the ground edge of the glass; these are called the stationary arcs; the other two arcs (*f*, Fig. 16 and Fig. 20), diametrically opposite the stationary ones, exert a slight pressure against the edge of the mirror, by means of springs, for the purpose of seating the mirror against the stationary arcs and holding it there; this pressure need amount to only a very small percentage of the mirror's weight, for all of the lateral pressure due to the weight of the mirror when the latter is inclined is carried by a strong metal counterpoising ring of T section (*g*, Figs. 16 and 17); this completely encircles the edge of the mirror, and fits it loosely, a band of leather or thick felt paper being inserted between the ring and the glass. For convenience in description, imagine this ring to be suspended from the tube above, by means of three short wires, so that if the mirror were removed the ring could swing freely in its own plane. The ring is pressed up against the edge of the mirror, when the latter is inclined, by a system of twelve short weighted levers (*h*, Figs. 16 and 17) which hang perpendicular to the plane of the ring. These levers are suspended from the cell-plate behind the ring, by means of ball-and-socket joints, as shown in Fig. 17, or preferably, to reduce friction, on pivoted universal or Hooke's joints. The ends of the short upper arms of these levers fit loosely into holes in the ring; the long lower arms carry lead weights (*i*, Figs. 16 and 17) which are capable of slight adjustment.

Assuming that the counterpoising ring weighs 400 pounds, so that the combined weight of ring and mirror is 2,400 pounds, the adjustment of the edge-support levers is effected by turning the entire cell to a vertical plane, with the mirror and ring removed, and adjusting each of the twelve lead weights until it just balances a standard weight of 200 pounds hung on the short arm of the lever at the point where this is to touch the ring.

I regard the use of a support-system which will fulfill all of the conditions mentioned at the beginning of this chapter as absolutely essential for large mirrors. Only those who have tested large mirrors and combinations of mirrors in the optical shop, and those who have actually used large reflecting telescopes, can fully appreciate the necessity of a support-system which will both support the mirrors without constraint and flexure, and define their positions permanently with respect to the tube and axes, in all positions of the telescope. These conditions can now be attained easily and economically; without them it is folly on the one hand to expect good definition and successful photographs, or, on the other hand, to complain that the reflecting telescope is subject to serious inherent difficulties which cannot be overcome. In the case of large mirrors in which the ratio of thickness to diameter is not less than as 1 to 9 or 1 to 10 the support-system just described floats the mirror so perfectly in all positions which can occur in actual use that no flexure or distortion can be detected with the most sensitive optical tests. Furthermore, with the method of edge-support described, and in the case of the 5-foot mirror weighing a ton, no lateral shift amounting to 1-2000 inch can occur when the mirror is turned in extreme oblique positions.

In Figs. 17 and 18 is shown the massive cell-plate of cast-iron which carries the mirror and its support-system, and which is connected to the short cast-iron section of the tube; this connection is made by means of strong adjusting screws, by means of which the mirror and its support-system, as a whole, are adjusted for collimating the mirror; these adjusting screws are shown at *k*, Fig. 18. Additional screws are also shown at *l* in this figure; these are backed out of the way when collimating is being done; when this is finished they are brought into position, and assist in bolting the cell-plate rigidly to the tube. As is shown in Figs. 17 and 18, the central part of the cell-plate, a circle about 50 inches in diameter, consists of open ribs or arms which allow free access of air to the silvered back of the mirror.

When the face of the mirror is to be resilvered, the cell-plate, support-system, and mirror are removed as a whole, and silvering is done in the manner described in the preceding chapter, without taking the mirror from its supports or disturbing the adjustments of the latter in any way. Furthermore, the mirror can be taken out of the telescope in this way, silvered, and replaced, without sensibly disturbing its collimation or the position of the focal plane. When the back of the mirror must be resilvered, which need not be done oftener than once in three or four years, the glass must of course be removed from its support-system.

This support-system, as described, may appear complicated and expensive; in reality it is not so, for all of the levers, plates, etc., used for the back-support can be exactly alike, as can also the levers used for edge-support; even when a greater number of levers than twelve are used the construction is simple and economical.

In Plate VII. is shown a 30-inch plane mirror supported at the back by twelve plates and nine levers as described above; the mirror is shown unsilvered, so that the plates are seen through four inches of glass. This is a part of the 30-inch cœlostat recently constructed from the writer's designs in the instrument and optical shops of the Yerkes Observatory.

(To be continued.)

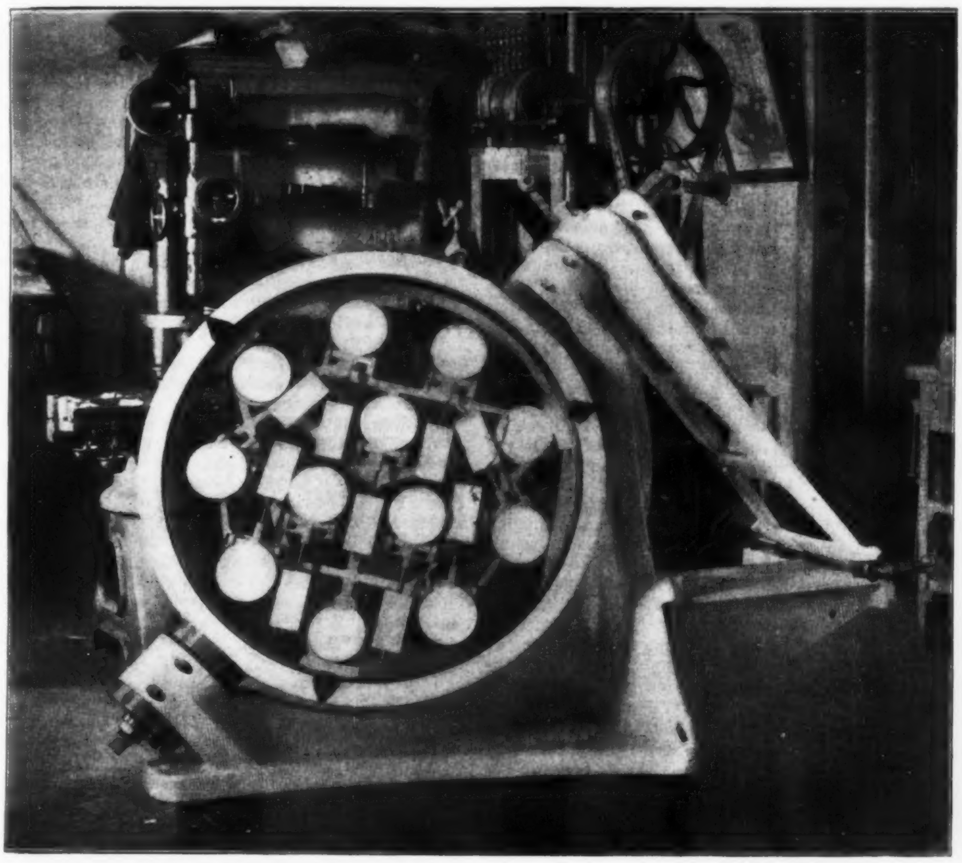


PLATE VII.—LARGE CŒLOSTAT WITH 30-INCH PLANE MIRROR. PLATES AND LEVERS FOR BACK-SUPPORT ARE SEEN THROUGH THE UNSILVERED GLASS.

LIGHTNING RODS.—K. von Wesendonck reiterates his contention that the chief use of lightning rods is not that they dissipate the atmospheric electricity and thus prevent lightning discharges, or rather convert them largely into a silent and gradual discharge. Such a silent discharge, he points out, would be accompanied by the luminous phenomenon known as St. Elmo's fire, which, however, is much rarer than thunderstorms in Europe. He experimented with two large plates, to the lower one of which a point was attached. He found that the silent discharge commenced as soon as the distance of the point above the lower plate reached a certain value, but that as soon as it did commence, it was accompanied by luminous effects plainly visible in the dark. He doubts the efficiency of hot gases from chimneys in dispersing accumulations of atmospheric electricity.—K. von Wesendonck, Physikalische Zeitschrift, July 15, 1904.

[Concluded from SUPPLEMENT No. 1515, page 24272.]

ICE-BREAKERS AND THEIR SERVICES.*

By ARTHUR GULSTON.

NAVIGATING in ice, although hazardous, is most fascinating work; it is always changing; difficulties to be overcome at a moment's notice are ever present. Think of the position of an ice-master in a breaker, with say one or two steamers following in his track! Down comes the fog; no astronomical observations can be made; all lights are blotted out; he cannot take a sounding on account of the ice; if he stops, the boat behind (if the master is not on the alert) will run into him, and this in turn applies to the second following boat. Add to this, that the ice is "on the move," but its direction is not certainly known, and the snow comes to help the complex problem! Only an iron nerve and a quick decision by those in charge of the ice-breaker can meet such a position, and if the vessel is among rocks or shoals, and in most places these dangers to navigation are present, the difficulties are indeed increased.

Ice pressures are far-reaching and serious in their results; as showing the distance they reach, one case came under my personal observation at Reval. A northwest gale had blown the drift ice at the mouth of the Gulf of Finland into Reval Bay, against the field ice at rest in the bay, thus forming an enormous pack at the mouth of the bay, fifteen miles from the harbor. The result of this great pressure was shown on the outside of the stone mole, or breakwater of the outer harbor, where the ice was pressed 32 feet in height, destroying a wooden pier used for steamboats; the amount of ice pressed up represented many thousands of tons in weight.

The captain or ice-master has to exercise considerable care in cutting out vessels fast in the ice, and the procedure is to pass across the bow and then the stern of the fastened vessel. Endeavor should be made to crack the ice in some direction toward the ends of the vessel, before passing her in a parallel direction, in order to obviate as far as possible all chances of crushing the steamer's sides. In passing close alongside, the ice may "up-end" between the vessels, with the result that the ships fall together, and the "drag" of the ice-breaker is sure to fetch the other vessel alongside, unless the speed of the breaker is great enough to clear the other vessel. This has actually occurred in the writer's experience in the Gulf of Finland, when a train of eight steamers were following the "Ermack" to Cronstadt, and but for the timely assistance of the "Ermack" life would have been lost.

Another type of steamer used in the ice is the ice-breaking passenger and mail steamer. There are not many of these vessels at work, and of course they are not able to force the packs as readily as an ice-breaker can. They are fitted with every requisite for winter service, including electric projectors. As a rule they propel themselves through the ice at night as well as by day. Three vessels of this type, the "Express" and the "Abo," running between Stockholm and Hangö, and the "Bore," running between Stockholm and Abo, keep up a steady timetable.

Three of the mail boats running between Kiel and Korsoer are also examples of this type and are well known to many English travelers. The latest, the "Prinz Sigismund," is 205 feet long and has twin screws of 1,200 I. H. P.

The "Arcturus" and "Polarius," of Helsingfors, are splendid types of these vessels. They were built in Dundee, are 281 feet long and 3,500 I. H. P. They are first-class passenger vessels, are magnificently found in all respects and have a speed in open water of $14\frac{1}{2}$ knots.

I have seen the "Arcturus" make a splendid entry to Reval through the canal cut in the ice by the "Ermack," although in passing through the great pack at the entrance of the gulf, she had too much speed on and damaged her sides below the waterline—in fact, she squeezed herself badly. These boats run from Hull to Helsingfors, and are, therefore, ocean-going steamers.

The "Oihonna" and "Wellamo" are also handsome boats of the same class, but smaller in their dimensions.

The "Aegir" and "Linnea," of Helsingfors, are typical cases of ice-breaking cargo steamers. They trade regularly all the winter between Hangö and Lubeck; are 172 feet long, 15 feet draft, and 500 I. H. P., and are much strengthened over the requirements of the Registration Societies, and well arranged for winter navigation in open water and among ice.

The "Stanley" is an ice-breaking mail boat belonging to the Canadian government; she is occupied in running between Prince Edward's Island and Newfoundland, across the Gulf of St. Lawrence. During the winter the ice at times packs heavily from wind and tide pressure, but this vessel is well able to negotiate the packs she meets on her station. Her length is 208 feet, her beam 37 feet. She has a powerful engine, and is well found for the service, which at times is extremely arduous and hazardous.

The "Britannia," the first steamer of the Cunard Company, in 1844 became fastened in the ice in Boston Harbor; the townspeople arranged to help to cut her out; this was accomplished by sawing and breaking the ice, and by the aid of the vessel's paddle wheels, she reached the open water, as the townspeople of Boston made up their minds that the vessel should keep her sailing date. The distance that the "Britannia" had to be cut out was seven miles, and at that date this was a remarkable undertaking, and meant a great deal to the mail service between England and Canada. Mr. Nelson Cameron (the owner of the print from which the slide is made) inherited it from his father, who was on board the "Britannia" at the time she was fast in the ice. He had crossed the Atlantic as a passenger over 100 times in the Cunard line, and his yarn about the Boston ice pack was the best of the many he could tell of his experiences in the early days of Atlantic steam navigation.

The old-time whalers of Dundee and other ports, some of which are now engaged in Polar work, either on Polar expeditions or whaling, are essentially ice-breakers of a type; they are built entirely of wood, the bows sheathed with iron, and many daring deeds have been done with some of these vessels in the Polar seas.

We must not except from this class Dr. Nansen's "Fram;" she is well designed to withstand shocks and ice pressures, and this she has proved in her long endurance in Polar ice on two expeditions, having but lately returned from four years' service in Davis Straits, under the command of Capt. Sverdrup.

Nor must we overlook the "Discovery" of the National Antarctic Expedition now at work in the immense ice of the Southern Polar Ocean, specially built for service in the ice; and the "Scotia" of the Scottish National Expedition, known for long as the whaler "Heckla," built of wood, having sides 24 inches thick, and 9 feet of solid timber at the bow wherewith to attack the ice.

There is without doubt a large field for winter service steamers, and their number and power will probably increase in the future, especially as more information regarding ice is obtained from winter to winter, and the method of dealing with ice navigation becomes better known.

Another type of vessel for use in winter is the railway ferry ice-breaking steamer. This useful type of steamer represents many problems, and is by far the most difficult to design and arrange. Some of the vessels are of great size, and those best known to us are used by the Danish State Railways, between the islands of the Great Belt and the mainland. The State possesses no fewer than fifteen or sixteen of these steam ferries; of these only the five largest have two lines of rails, the remainder one line, and only three have screws—two being twin screw—the remainder having paddle wheels.

The "Zyeland," built at Copenhagen, is 171 feet long, has a draft of 11 feet 6 inches. Her indicated horse-power is 1,200, and she is a very useful ship. She crosses between Korsoer and Nyborg, on the main route of railway between Denmark and Germany, a ferry of about twenty miles.

Another fine railway ice-breaking steamer is the "Malmo," built at Malmo, running across the Sound between Copenhagen and Malmo, a distance of sixteen miles. She is a powerful vessel, 268 feet long. She draws 10 feet 6 inches water, and has a speed in open water of 13.25 knots. Her engines are triple expansion, she has a space on deck for eighteen railway wagons, and successfully copes with the peculiar conditions of the ice at this station.

On the main route of railway between Denmark and Sweden at Elsinore, there is a railway ferry steamer, the "Heslingborg," built at Elsinore, and only lately put to work. She is 177 feet long, has one line of rails, and is fitted with a screw propeller at either end. The distance across is eleven miles. She has compound engines of 800 horse-power, has attained a speed, in open water, of 10.9 knots, and has to attack heavy packed ice during the winter.

The Danish State Railways are now establishing a railway ferry between Gjedser, in Denmark, and Warnemunde, in Mecklenburg; the distance across is twenty-four miles. There are to be four steamers on this route, two twin-screw and two paddle, 285 feet long. They are to have two sets of rails, and will be able to take on four express bogie coaches of 65 feet in length. Their speed will be 14 knots an hour, and the intention is to keep up an express railway service between Germany and Denmark all the year, without the passengers having to leave the carriages, and at times during winter the ice sets heavily on the land.

Following these vessels come the famous railway ferry ice-breakers at Saratoff on the River Volga, which are used for keeping up the services of the Riazan Ouralsk Railway across this mighty river. The river is icebound for several months during the winter. The fleet consists of two steamers, one being an ice-breaker, whose duties consist of taking across the passengers, mails, and luggage. The distance across is less than a mile, and she is generally able to accomplish the journey in twenty minutes to half an hour when the ice is fast.

The other steamer is a railway ferry ice-breaker, 243 feet long, 55 feet 6 inches broad. She is capable of taking twenty-four of the railway company's large goods wagons at once, the loading and unloading of which are very expeditiously carried out. She has four lines of rails, and two very powerful hydraulic lifts at the fore end of the vessel to raise the trucks from the deck to the railway level. As the Volga changes its level all the year round, and the difference of levels at this point is about 45 feet, it is necessary to introduce the hydraulic system on the boat, otherwise four large double lifts would have to be fitted at the four railway piers, two of which are high level, and two low level. These low level piers are submerged during the period of high water which occurs in spring during the melting of the snow and ice.

The ferry steamer is assisted by the ice-breaker before referred to when the ice gets difficult to negotiate, as occasionally the canal cut in going one way is closed before the return journey is begun. These steamers are entirely fired by oil fuel, the ice-breaker going through her trials on the Tyne and steaming out to St. Petersburg under this system, which has given entire satisfaction.

As these two vessels had to pass through the system of locks on the Marinsky Canal from Lake Ladoga to the River Swer, and so to the mighty River Volga, it was necessary to build them so that they could be parted to enter the locks; the ice-breaker in halves, and the railway ferry boat in four portions. This gave rise to considerable ingenuity of design, and a large amount of work, as each half of the ice-breaker when separated had to be placed in a barge to pass through the canal system, and, of course, all the work had to be gone through again in joining them up.

These vessels were sent away from Walker Shipyard bolted together at the division bulkheads, and all in readiness for parting, which operation took place on the River Neva, some distance above St. Petersburg. All disconnecting and coupling up had to be done afloat, which rendered the task all the more complex.

I now wish to describe the "Scotia," a most interesting boat built at Walker, to the order of the Intercolonial Railway of Canada, for service across the Strait of Canso, between Cape Breton Island and Nova Scotia. She is a typical ice-breaker. Either end of the vessel is intended to be bow or stern at will, so that in working she does not require to turn round in entering or leaving her landings, the gangways resting on either end of the ship when lowered for loading or discharging the trains. As her ends are alike, both propelling engines are on the center-line of the vessel, and can be coupled to each other, if so desired. The ice in which the vessel has to work is blown into the Straits from the Atlantic or the Gulf of St. Lawrence, and at times it becomes very tightly packed.

The vessel is 269 feet long, draws loaded 14 feet, and has a speed in open water of eleven knots. Her framing is exceptionally strong, and her shell plating in way of the ice-belt is very heavy, as she has to withstand severe local shocks.

The vessel has three sets of rails of the 4-foot $8\frac{1}{2}$ inch standard gage from end to end, and is designed to carry nine Pullman or Corridor bogie sleeping cars, 80 feet long, each weighing 52 tons unloaded. The largest bogie saloon cars in England are 67 feet long. The decks of the steamer are enormously strengthened by deep girders and pillars throughout, so that she can, when necessary, take over a locomotive and tender, which, on the Intercolonial Express of Canada, weigh 120 tons with steam up. The vessel has four boilers, and the disposition of the four funnels and the captain's bridge gave rise to considerable ingenuity. The ship is entirely controlled from the bridge, as the center of the deck must be kept clear for the coaches.

In this steamer the descent of the rolling stock on to the deck of the steamer is somewhat steep, and consequently very large buffers are provided to catch the coaches should the brakes fail, as a run into the water at the other end of the ship is not part of the Railway Company's schedule at the Canso Ferry.

As time is an all-important factor when the train is being put on board, three coaches are run on and taken off at one time, the taking off being done by a small shunting engine.

The next railway ferry ice-breaking steamers before us are the "St. Marie" and the "St. Ignace," working across the Straits of Mackinaw, between Lakes Huron and Michigan, a distance of seven miles. Both these boats are built of oak, and are sheathed with iron in way of the waterline. The "St. Marie" is 304 feet long, has 4,000 I. H. P. She has a propeller at either end, fitted with the idea that it helped her immensely to clear the landings. This vessel takes her trains on at the bow, has three lines of rails, and is, with her sister vessel, designed to work in ice up to 24 inches thick. The power of the engines of the "St. Marie" is nearly equally divided on the propellers. She commences work as soon as the ice begins to form at the setting in of the winter, and crosses in the same channel. As the ice seldom moves at Mackinaw, she has not much trouble in keeping the ferry open. She is splendidly handled, and the manner in which the trains are put on board and taken off, would be a revelation to many railway officials in this country.

Another most interesting ice-breaking railway ferry steamer is the "Transfer" of the Michigan Central Railway Company, which ferries the trains of several railways across the River Detroit, at the city of Detroit, situated between Lake St. Clair and Lake Erie. She is 280 feet long, and is the only example at the present time of a steamer having both paddle wheels and screw engines. She is built with a spoon-shaped bow and heavy scantlings; has three lines of rails from end to end of the vessel, and can carry twenty-one bogie trucks, or twelve passenger bogie cars. Her paddles are 27 feet 6 inches diameter, and the floats are heavily protected by plating; the wheels are immensely strong, weighing 46 tons each. She steams through ice six inches thick easily at ten knots an hour, and is in many ways a remarkable vessel. One feature in her machinery is that the paddle wheels are geared to the engines, which leaves the railway deck undisturbed by any opening for the crankshaft usually seen in a paddle steamer.

Another vessel of the same class, and owned by the same company, is the "Michigan Central;" she has paddle wheels only, is 263 feet long, and carries a heavy freight train.

There is also at Detroit another fine railway ice-breaking ferry boat, the "Ontario," belonging to the

* Read before Society of Arts.

celebrated Canadian Pacific Railway Company; she is 297 feet long, and has large compound paddle-geared engines.

At the port of L'Arbor, at the head of Lake Michigan, there is a fine car transfer ice-breaking steamer, "Ann Arbor," belonging to the Toledo and Ann Arbor Railway Company. She crosses the head of this great lake a distance of sixty miles. The freight cars enter the vessel at the stern. She is decked over for a considerable distance from the bows, is 267 feet long, and 52 feet beam, draws 12 feet of water, and has a displacement of 2,550 tons. She is built of oak, has twin screws at the stern, and one propeller at the bow, all driven by compound horizontal engines. Her speed in open water is ten knots an hour, and at times she has very heavy packed and field ice to deal with.

The "Nederland" is an example of the usual type of large passenger screw ferryboat in use at New York to cross the harbor. In winter the ferry steamers have to pass through the ice that accumulates and moves up and down New York Harbor during times of hard frost.

The "Solano." This magnificent ferryboat plies across the Straits of Carquinez, situated some thirty miles north from San Francisco. She is constructed of oak, is 434 feet long by 116 feet over the guards of her paddle boxes. The trains enter from either end. She is owned by the Central Pacific Railway Company, whose transcontinental expresses are daily ferried over by this steamer.

I will now describe to you one of the finest railway ice-breaking ferry steamers afloat—the "Pére Marquette"—built by Messrs. Wheeler, of Michigan. This vessel has to cross the center of Lake Michigan, between Ludington and Manitowoc, a distance of some fifty-six miles, in all weathers, and encounter open water, heavy, solid, and packed ice, and steam through strong gales and high seas. She is 350 feet long, 56 feet beam, and when fully loaded has a displacement of 4,950 tons on 12 feet 3 inches draft. She is strongly constructed, and her shell plating is very heavy. She has a splendid arrangement of cabins in the deck house, and every accommodation for first-class express service where the passengers may be on board all night. Her engines are twin screw compounds, 135 pounds pressure, and 4,000 I. H. P.

The rolling stock enters at the after end, and as there are four lines of rails, she can take on fourteen 80-foot corridor saloon cars, weighing about 56 tons each, loaded, or thirty freight cars. This steamer is truly a palatial floating hotel, and does a large amount to attract custom to the Flint and Pére Marquette Railroad Company. All the rolling stock on board is secured and blocked by mechanical means, to prevent movement in a sea-way, or when striking ice at high speeds.

On the Great Lakes of America, there are no fewer than fourteen car ferry routes.

From these vessels we come to the famous ice-breaker "Baikal," on Lake Baikal, in the center of Siberia. This splendid vessel was built to connect the eastern and western ends of the Siberian Railroad, which, as you know, makes a continuous railway from Ostend to Vladivostock, in Eastern Siberia, and Port Arthur, in Manchuria, some seven thousand miles long.

Now Lake Baikal lies N. E. to S. W., and all round the S. W. corner of the lake, the Tartar mountains impinge on the lake itself; and to make this railway round the corner of the lake meant some 500 tunnels and bridges, more or less; and as the valleys are very steep, and work can only be carried on during the open months, the engineering difficulties are apparent. Also, landing from the lake is out of the question, as the debris from the mountains and valleys prevents this; and as very strong gales blow without warning on this stretch of water (principally from the northeast), the lake being 500 miles long, and nearly 4,000 feet deep, very dangerous seas get up, making it impossible for vessels to lie at the southwest corner. In the face of these and other difficulties, and the time that it would occupy to construct this portion of the railroad, Prince Khilkoff, the Minister of Railways and Communications in Russia, decided to order an ice-breaker to ferry the train across, and intrusted this most important problem to my firm, on account of their great experience in designing and constructing this class of vessel.

The field ice on Lake Baikal forms 36 inches deep, and owing to the gales, it packs heavily, particularly toward the Tartar coast, even grounding in some cases, and, owing to the extreme cold coming at times quite suddenly, and the ice being land-locked, it contracts and cracks, leaving dangerous crevices across the lake. This lasts for well over four months of every year.

Until lately, all crossing Lake Baikal in winter was by sledges over the ice, and as severe blizzards and fogs are common, it sometimes happened that an unfortunate traveler, driver, horses, and sledge would go down one of these cracks.

The distance of the ferry across the lake is 52 miles. The vessel is 290 feet long, and 4,200 tons displacement, and her draft, under ordinary working conditions, is about 19 feet.

She has three sets of triple expansion engines, one at the bow and two at the stern. The principle of subdivision is carried out in the highest degree, and a large number of compartments would have to be pierced before she would sink. The vessel has luxurious accommodation, and a promenade deck for the use of passengers while they are making the passage across.

During the winters that this enormous steamer has been at work, she has proved herself to be most successful in keeping the service open under difficulties of ice navigation that were unknown, and therefore even unthought of, during her construction. Of course, there was no knowledge of the ice as regards navigating purposes in Lake Baikal until this vessel went to work.

The hull was completely erected, marked, taken down, and shipped inside of six months, and 2,700 tons weight, in 6,900 packages, had to be transshipped for some 1,500 miles across Siberia by boat to the place of re-erection. The boilers (of which there were fifteen) had to be kept under 20 tons in weight, for transshipment purposes, and even these great pieces were moved in sledges by the aid of hand and pony power from the railway trucks to the ship.

The vessel has three lines of rails, entered from the forward end; the center track is very strong, to carry the locomotives, which, on this railway, weigh, loaded with tender, from 94 to 104 tons.

Her consort, the "Angara," is a fine ice-breaker, having one screw, 1,500 I. H. P. triple expansion engines and loco boilers. These boilers were adopted so as to get over the difficulty of transshipment from St. Petersburg to Lake Baikal. She is a most successful ice-breaker, making her passages with the utmost regularity with mails and passengers.

I will conclude this paper with a reference to the "Ermack." This magnificent piece of naval architecture is 335 feet long, 71 feet beam, and has a displacement (with coals on board) of 8,000 tons on a draft of 22 feet.

As the "Ermack" was built for Polar enterprise, as well as for ice-breaking in the Baltic, she was designed to receive the very severe blows that locally strike her when among the enormous ice of the Polar ocean, and ice pressures that may lift her clean out of the water, leaving her ice-borne.

Her bow engine, though successful in one-year-old ice, has been removed, as the shape at the bow to admit the propeller was not suited to the requirements of the Polar ice. Her speed through 24 inches of solid ice, with 6 to 12 inches of snow on the top of it, is 9 knots an hour, and she can charge and demolish packs of ice 20 to 35 feet in thickness. In Polar ice the speed has to be kept at about $2\frac{1}{2}$ to $3\frac{1}{2}$ knots an hour, as one is apt to lose control of the vessel in this enormous ice, and the local shocks become very severe when she is charging about at her own "sweet will" among the Palæocrystic ice. She has proved herself to be of enormous use on her station on the Baltic coast of Russia, where she can negotiate any ice, and can safely bring out of danger all steamers that she goes to assist. In one short season, she rescued and assisted shipping of over two millions sterling value, and, in another winter, she salved the Russian battleship "General Admiral Apraxine," of £750,000 value.

With the "Ermack" in the Baltic, there is no difficulty in Russia putting to sea her fleet, which usually winters at Cronstadt, as the "Ermack" could easily guide them to open water should necessity arise; and there is nothing to prevent this vessel herself being made an armed cruiser.

SCIENCE NOTES.

M. Bertillon, the French anthropometrician, whose system of criminal identification is well known, has devised an ingenious system of metric photography, by means of which is furnished mathematically exact information concerning the dimensions and relative positions of the objects portrayed upon the photograph. Hitherto such calculation has only been possible by means of laborious trigonometrical calculi, but in this latest device simple arithmetical calculations only are necessary. For these purposes the picture or print has a scale of distances on one side below the line of sight. For instance, suppose the print depicts a scene in the street. A carriage appears in the scale reading 10 meters. The figure gives the distance the vehicle was from the camera. A building is against 30 meters, and a pedestrian 3 meters of the scale, and this represents the distances of these two objects from the lens. In this manner the precise distance of any object can be easily and quickly ascertained. On the opposite of the picture is a scale which supplies dimensions. On a level with the building appears the figure 60. This indicates that the picture is one-sixtieth of its size at that particular point, and so on with every object in the photograph. It will be recognized, however, that the correctness of the calculations is entirely dependent upon the mathematical accuracy of M. Bertillon's apparatus, which condition the inventor states is mathematically fulfilled.

Dr. Th. Tommasina, of Geneva, Switzerland, some time ago investigated an interesting phenomenon connected with the radio-activity taken by a heated wire and by any substances submitted to the action of the latter. In the course of these researches he was led to design proper devices for augmenting the intensity of the phenomenon, so as to facilitate its production and to allow the intensity and duration of the radio-activity to be measured. A similar quantitative determination for various bodies has in fact a very high importance for a possible therapeutical utilization of this radio-activity, which being independent of any noxious substance, may be introduced into the organism through the digestive organs, or even injected directly into the blood. As stated in a memoir recently presented to the French Academy of Sciences, he finally solved the problem by means of Röntgen rays. Tommasina realized that the intensity and duration of the radio-active power assumed by a body is proportional to the state of ionization of the medium, if this state be due to an emission of X-rays, so as to be proportional to the intensity and duration of this emission. Any suitable outfit for producing X-rays is sufficient to impart to any substance a fairly intense radioactivity, which may last for some days. Even living organisms are liable to be radio-actively influenced without harmful effects, as the Röntgen rays need not strike the subject. The Crookes tube may, for instance, be located in a cabinet left ajar, the rays being directed toward the interior of the cabinet, so that the ionization of the air is propagated by diffusion. Patients may accordingly be activated while in bed, it being sufficient to place the bed on insulating supports, and to connect the patient with the internal coating of a Leyden jar, the external coating of which is grounded, as is the positive terminal of the induction coil. Between the negative terminal of the coil and the inner armature of the Leyden jar, rapid discharges one centimeter in length are allowed to pass. Between the same armature and the body to be activated, there should, however, be inserted either a wet string, or preferably a vacuum tube of small resistance. A similar system gives an activation of greater strength than the activity of hot wires (pyro-radio-activity); and as the same outfit is susceptible of being used for the production of X-rays, Dr. Tommasina eventually adopted it. By this means the air may be ionized to any desired degree, so as to produce a perfect quantitative determination of the activity between rather extensive limits. Any solid body, both inorganical and organical (such as fruit, grass, and live animals), as well as any kind of conductive or insulating liquid, has thus been made radio-active. Any drugs both for internal and external use, and any material used for bandages, compresses, etc., as well as any solid or liquid food used for a special diet, may thus be radio-activated without introducing any trace of known radio-active body. As regards the therapeutical properties of the radio-activity, nothing can so far be stated; as, however, any radio-activity is found to be attended by ionization, there seems to be an influence facilitating electrolysis, or even giving rise to it. In that case a rather welcome action, with a view to a rapid and more complete assimilation of certain medicaments, such as, for instance, iron in the cure of anemia, should be anticipated. Moreover, radio-activity being apparently the cause of the therapeutical properties of certain mineral waters, these may be augmented by increasing radio-activity on the lines above mentioned.

TRADE NOTES AND RECIPES.

Brass Varnish for Physical Instruments.—Reduce to powder 160 grammes of turmeric of best quality, and pour over it and 2 grammes of saffron, 1.7 kilogramme of spirit; digest in the warm for 24 hours, and filter. Next dissolve 80 grammes of dragon's blood, 80 grammes of sandarac, 80 grammes of elemi gum, 50 grammes of gamboge, 70 grammes of seedlac. Mix these substances with 250 grammes of crushed glass, place them in a flask, pour over this mixture the alcohol colored as above described. Assist the solution by means of a sand or water bath, and filter at the close of the operation.—Neueste Erfahrungen und Erfindungen.

Production of Worcestershire Sauce.—

Allspice	7.0
Cloves	3.5
Black pepper	3.5
Ginger	3.5
Curry powder	30.0
Spanish pepper (paprica)	3.5
Mustard	60.0
Shallots, cut up	60.0
Salt	60.0
Sugar	40.0
Tamarinds	120.0
Sherry	570.0
Wine vinegar	1,140.0

The freshly-reduced spices are gently boiled for an hour in the vinegar, adding a little more of the latter than is lost by evaporation. Next add the wine and, if desired, a little caramel for coloring. Let the whole stand for a week, strain it, and fill in bottles.—Neueste Erfindungen und Erfahrungen.

Reduction of Old Gold Solutions.—All liquids containing gold, with the exception of baths of which cyanide forms a part, must be strongly acidulated with chlorhydric or sulphuric acid, if they are not already acid in their nature. They are afterward diluted with a large proportion of ordinary water, and a solution of sulphate of ferroprotoxide (green vitriol) is poured in in excess. It is recognized that the filtered liquid no longer contains gold when the addition of a new quantity of ferric sulphate does not occasion any cloudiness.

Gold precipitated in the form of a reddish or blackish powder is collected on a filter and dried in an iron stove with weights equal to its own of borax, saltpeter and carbonate of potash.

The mass, roasted, is afterward introduced gradually into a fireproof crucible and carried to a white red heat in a furnace. When all the matter has been introduced, a stronger blast is given by closing the furnace, so that all the metal collects at the bottom of the crucible. On cooling, a gold ingot, chemically pure, will be obtained.

This mode of reduction is also suitable for impure chloride of gold, for baths of gilding with bicarbonate

or pyrophosphate, and also for the removal of gilding, but it is imperfect for liquors containing cyanides, which never give up all the gold they contain; the best means of treating the latter consists in evaporating them to dryness in a cast-iron boiler, and in calcining the residue in an earthen crucible at the white red.

A small quantity of borax or saltpeter may be added for facilitating the fusion, but it is not generally necessary.

The gold separated collects at the bottom of the crucible. It is red, if saltpeter is employed; and green, if it is borax.—Translated from La Science Pratique.

ENGINEERING NOTES.

While the internal-combustion engine has made rapid strides during recent years on land, its use for marine propulsion has been mainly confined to small craft. The progress made in gas production from coal in the simple apparatus known as the "suction gas producer" has, however, drawn the attention of marine engineers to the possibilities of applying the gas engine to large vessels. Some barges on German canals have been propelled successfully by gas engines supplied with fuel from suction producers. But a more important venture is now in hand in England. Messrs. Holzapel, on the Tyne, have a vessel of some 800 tons burden building for propulsion by gas engines supplied with coal gas from suction gas producers. The chief objection at present to the gas marine propulsion arises from the fact that gas engines are difficult to control in speed, and not easily reversible.

The Milwaukee flushing tunnel, through which water from Lake Michigan is pumped into the Milwaukee River, has remained a unique engineering work to the present time. Before it was completed, under the direction of Mr. George H. Benzenberg, the river was a detestable nuisance, while to-day it is so fresh and clean that fish enter it. The Gowanus Canal in Brooklyn is in a condition like that of the Milwaukee River before the construction of the flushing works. It is foul with the refuse of the gas works and factories and gives off a vile stench at times. To remedy its condition, Mr. Henry R. Asserson, engineer of sewers of the borough, has recommended the construction of a tunnel and pumping plant which will force water from the East River into the head of the canal, and thus create in the latter a sufficient current to carry off the refuse which pollutes it. The conditions favorable for such works are so rare that the Brooklyn case is of special interest.—Engineering Record.

The New York canal improvements need not worry the taxpayers of the State any more if the bids received for the first contracts can be taken as an indication of what the work will cost. In the Engineering Record there was recently published an itemized summary of these tenders, which shows that the cost of the work will probably be well within the engineer's estimates. It is interesting to observe that these bids are all based on an eight-hour working day, while the eight-hour law has just been declared unconstitutional. The terms of the contracts have been so drawn that eight hours are specified as the length of the working day, apart from any law on the subject; in other words, the contractors bind themselves to work their men in eight-hour shifts as a part of their contract obligations. Now that the law has been declared void, it will be interesting to observe whether future contracts will be drawn up on this basis, which materially enhances the cost of the work over the price that a private corporation would pay for it.

Accidents on railways are attracting so much attention just now that it is particularly interesting to review the figures given in the report of the Interstate Commerce Commission for the year ending June 30, 1904. There were 43,266 employes injured and 3,367 killed in 1904, as compared with 33,711 injured and 2,516 killed in 1902. The figures for 1903 are intermediate between those for 1902 and 1904. In 1904 there were 8,077 passengers injured and 321 killed; in 1902, 6,089 injured and 303 killed; in 1903 there were 6,973 injured and 321 killed. The increase in the number of deaths of passengers in train accidents in 1904 compared with 1903 is $64\frac{1}{2}$ per cent. There were ten unusually disastrous accidents during the year. The number of deaths resulting from these accidents, eight of which were collisions, is about 23 per cent of the total number killed in all the train accidents of the year, which comprise over 6,000 collisions and 4,800 derailments. Although there has been earnest discussion of the subject in the public press, it is noticeable that the very magnitude of the question involved appears to have produced some confusion, and in the multitude of causes assigned the real question in many cases has been lost sight of. The paramount requirement, as pointed out in the last annual report, is an effective measure for the prevention of collisions.

It is understood that the various systems of wireless telegraphy now in use are to be tested in the annual naval maneuvers in the Caribbean Sea. Plans are being made for elaborate tests, and a majority of the vessels participating will be equipped with the wireless apparatus. Two or three different systems will be used and every effort will be made to intercept wireless messages and to break the lines of transmission. The vessels of the squadron will, as far as possible, be controlled by wireless telegraphy from the beginning of the maneuvers until the fleet comes north to Pensacola in March for target practice. Every effort will be made to test the efficiency of the instruments now used by the government.

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